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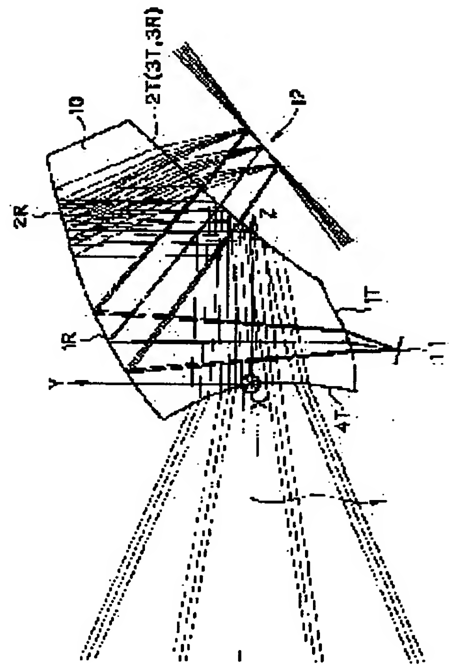
(54) SCANNING OPTICAL SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a small scanning optical system composed of few optical elements.
SOLUTION: The scanning optical system 10 makes a light source beam almost parallel in the tracing of arriving order of beams on an image surface (surface to be scanned) from a light source 11, with a converging optical system composed of a first transmission surface 1T, a first reflecting surface 1R and a second transmission surface 2T. The reflecting deflection of the light source beam made into an almost parallel beam is performed with a two-dimensional scanner 12. The beam subjected to reflecting deflection is imaged on the surface to be scanned with an image forming optical system composed of a third transmission surface 3T, a second reflecting surface 2R, a third reflecting surface (total reflection) 3R and a fourth transmission surface 4T, and the surface to be scanned is scanned two-dimensionally.



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CLAIMS

[Claim(s)]
[Claim 1] Scan optical system to which a field by the side of a scan layer-ed is most characterized by to include a page [2nd / or more] reflector containing the 1st [at least] page of nonrotation plane of symmetry which said optical member has optical power and carried out eccentricity to a shaft top chief ray in an independent operating surface of a transparency operation in scan optical system characterized by to provide the following in a field where said image formation optical system has optical power of said optical member including an optical member An optical deflection means to deflect light from the light source and to scan on a scan layer-ed Image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed
[Claim 2] The light source Image formation optical system which carries out image formation of the light deflected by condensing optical system which makes light from said light source abbreviation parallel light, optical deflection means to deflect injection light from said condensing optical system, and to scan on a scan layer-ed, and said optical deflection means to a scan layer-ed It is the scan optical system equipped with the above, and is characterized by a field of the last of said condensing optical system which injects from said condensing optical system and carries out incidence to said optical deflection means, and a field of the beginning of said image formation optical system which carries out incidence to said image formation optical system from said optical deflection means being the same fields.
[Claim 3] The light source Condensing optical system which makes light from said light source abbreviation parallel light An optical deflection means to deflect injection light from said condensing optical system, and to scan on a scan layer-ed Image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed It is the scan optical system equipped with the above, and, as for said prism member, said scan optical system is characterized by said a part of condensing optical system and including said a part of image formation optical system at least at least including a prism member.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the scan optical system which deflects the light emitted from the light source with an optical deflection means about scan optical system, and carries out the two-dimensional scan of the irradiated plane.
[0002]
[Description of the Prior Art] There is a thing as shown in drawing 10 and drawing 11 as an example of the conventional scan optical system. In the case of drawing 10 (JP,8-327926,A), first, according to the condensing optical system which consists of a collimator lens 52, a slit 53, and a cylindrical lens 54, this scan optical system collimates the light of the light source 51, and leads it to a rotating polygon 55. The 1-dimensional image formation side 57 is scanned with the image formation lens 56 which consists of two lenses in the light by which the reflective deflection was carried out by the rotating polygon 55.
[0003] In the case of drawing 11 (JP,8-146320,A), after making light of the light source 61 parallel by the collimator lens 62 and carrying out a reflective deflection by the deflection means 63, the two-dimensional scan of the irradiated plane 65 is carried out with the image formation means 64.
[0004]
[Problem(s) to be Solved by the Invention] However, since there are many optical elements which constitute optical system in the case of drawing 10 , the precision of the assembly adjustment for obtaining required optical-character ability becomes severe, and cost also increases. Moreover, in the case of drawing 11 , the concrete configuration of optical system is not indicated.
[0005] Made in order that this invention may solve the trouble of such conventional technology, the object is offering the small scan optical system constituted by few optical elements.
[0006]
[Means for Solving the Problem] The 1st scan optical system of this invention which attains the above-mentioned object In scan optical system which consists of an optical deflection means to deflect light from the light source and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed Said image formation optical system most in a field which has optical power of said optical member including an optical member a field by the side of a scan layer-ed in an independent operating surface of a transparency operation It is characterized by including a page [2nd / or more] reflector containing the 1st [at least] page of nonrotation plane of symmetry which said optical member has optical power and carried out eccentricity to a shaft top chief ray.
[0007] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0008] The operation effect of this scan optical system is explained. By reflecting nonrotation plane of symmetry which has optical power and carried out eccentricity to a shaft top chief ray in a page [2nd / or more] reflector included the 1st [at least] page, optical system can be

miniaturized according to a collapsible effect. Since a reflector which has optical power has a lens operation and a deflection operation, its effect of a miniaturization is large.
[0009] In optical system which used a reflector which has optical power and carried out eccentricity to a shaft top chief ray, in order that a beam of light may carry out incidence of the optical power aslant to a reflector which had and carried out eccentricity, comatic aberration by eccentricity, astigmatism, etc. occur also by the axial Uemitsu line. This eccentric aberration can be amended by making this reflector into a revolution unsymmetrical side.
[0010] moreover -- although a problem that linear scan nature is not securable arises when making a reflector which carried out eccentricity carry out incidence of the light deflected by optical deflection means in scan optical system generally -- a reflector of image formation optical system -- a revolution -- linear scan nature is securable by considering as an unsymmetrical reflector.
[0011] Moreover, it becomes easy to use image formation optical system as a two-dimensional f arc sine theta lens or a two-dimensional ftheta lens, and to carry out the uniform scan of the scan layer-ed by using a revolution unsymmetrical side.
[0012] When a deflection angle uses an optical deflection means to change to a linear, like a rotating polygon (polygon mirror), the uniform scan of the scan layer-ed can be carried out by generating distortion of minus in image formation optical system, and using image formation optical system as ftheta lens. Moreover, when a deflection angle uses like a galvanomirror a deflection means which changes in the shape of a sine wave, the uniform scan of the scan layer-ed can be carried out by generating distortion (it being the distortion of minus, when a deflection angle is small and distortion of plus and a deflection angle are large) according to magnitude of a deflection angle in image formation optical system, and using image formation optical system as an f arc sine theta lens.
[0013] In this case, in a field which has optical power of image formation optical system, a beam-of-light location of each field angle is large, and since a diameter of the difference flux of light is also small, a field by the side of a scan layer-ed is the most effective [diameter] in amendment of distortion. If it is going to make this field into a combination side of two or more optical operations like a transparency operation, reflex action and a transparency operation, and a transparency operation, since an amendment operation of distortion will deteriorate according to a constraint for making it a combination side, distortion can be effectively amended by considering as an independent operating surface of only a transparency operation. Moreover, reservation of a field angle also becomes easy.
[0014] 2nd scan optical system of this invention is characterized by constituting said optical member as a prism member in the 1st scan optical system.
[0015] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0016] The operation effect of this scan optical system is explained. Generally, since a reflector must control an eccentric error severely from a refracting interface, assembly tuning becomes serious. However, this problem is solvable if a reflector of an optical member is constituted as 1st page of a prism member.
[0017] Moreover, since a beam of light which carries out incidence to a prism member from a deflection means is refracted by plane of incidence of a prism member, it can set up low the incident ray high of an axial outdoor daylight line to subsequent fields. Therefore, while being able to make optical system small, a bigger field angle is realizable. Moreover, since the subordination beam-of-light high of an axial outdoor daylight line becomes low, generating of comatic aberration etc. can also be controlled.
[0018] 3rd scan optical system of this invention is characterized by said optical member including the 1st [at least] page of a combination side of transparency and an echo in the 1st scan optical system.
[0019] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0020] The operation effect of this scan optical system is explained. Since two operations of transparency and an echo are performed in respect of the same, the number of pages which constitutes image formation optical system can be reduced, and image formation optical system can be made simple and small. In this case, if reflex action is considered as a total reflection

operation, in addition, it is desirable. If not total reflection but an echo with a reflective film tends to perform an echo in a combination side, it is necessary to form a reflective film for reflectors in a transparency field for transparency sides, and another distant location. For this reason, problems, like that optical system is enlarged and generating aberration increases arise. Moreover, since it is necessary to produce a reflective film, cost rises.
[0021] 4th scan optical system of this invention is characterized by being the 3rd page configuration said whose prism member includes the 1st page of a combination side of transparency and an echo in the 2nd scan optical system.
[0022] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0023] The operation effect of this scan optical system is explained. When using a prism member of the 2nd scan optical system, plane of incidence to a prism member, a page [2nd] reflector, and a injection side from a prism member are needed at least. Since a prism member can be constituted from minimum number of pages of the 3rd page which consists of combination sides, transparency sides, and reflectors, a prism member can be made simple and small.
[0024] Condensing optical system to which the 5th scan optical system of this invention makes light from the light source and said light source abbreviation parallel light, In scan optical system which consists of an optical deflection means to deflect injection light from said condensing optical system, and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed It is characterized by a field of the last of said condensing optical system which injects from said condensing optical system and carries out incidence to said optical deflection means, and a field of the beginning of said image formation optical system which carries out incidence to said image formation optical system from said optical deflection means being the same sides.
[0025] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0026] The operation effect of this scan optical system is explained. Since it is necessary to detach this location of the 2nd page when making into a separate field "a field of the last which constitutes condensing optical system" and the "first field of image formation optical system" which are a field before and behind an optical deflection means, in follow light line tracking which goes to a scan layer-ed from the light source, it is necessary to detach a field before and behind an optical deflection means and an optical deflection means, or to enlarge a beam-of-light incident angle over an optical deflection means.
[0027] However, optical system will be enlarged if a field before and behind an optical deflection means and an optical deflection means is detached. Moreover, since area of an optical deflection means will become large if a beam-of-light incident angle over an optical deflection means is enlarged, it becomes difficult to secure a big deflection angle and high deflection frequency (scan frequency). Especially this serves as a big trouble in the case of an optical deflection means which consists of single reflectors like a micro machine scanner manufactured using micro machine technology which is indicated by JP,10-20226,A.
[0028] A beam-of-light incident angle [as opposed to the same field, then an optical deflection means for a field before and behind an optical deflection means] can be made small. Consequently, since area of an optical deflection means can be made small, a deflection angle of an optical deflection means can be enlarged, or deflection frequency (scan frequency) can be made into a RF.
[0029] 6th scan optical system of this invention is characterized by an optical operating surface before and behind said optical deflection means being a transparency side in the 5th scan optical system.
[0030] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0031] The operation effect of this scan optical system is explained. If an optical operating surface before and behind an optical deflection means is made into a reflector in follow light line tracking which goes to a scan layer-ed from the light source, since both a field (reflector 1) of the last which constitutes condensing optical system, and the first field (reflector 2) which constitutes image formation optical system will turn into a reflector In order to prevent incident light to a reflector 1, interference of a reflective mold optical deflection means, and the reflected light in a reflector 2 and interference of a reflective mold optical deflection means The need that

enlarge a beam-of-light incident angle to a reflective mold optical deflection means, enlarge a field before and behind a reflective mold optical deflection means (reflector 1= reflector 2) and distance of an optical deflection means, or plane of incidence to an optical deflection means and a horizontal-scanning side make an angle (it is not parallel) and of making it like arises. However, by each method, problems, like amendment of eccentric aberration to which magnitude of optical system becomes large to which area of an optical deflection means becomes large becomes difficult arise.
[0032] A transparency side, then such a trouble are [an optical operating surface before and behind an optical deflection means] cancelable.
[0033] 7th scan optical system of this invention is characterized by said image formation optical system including the 1st [at least] page of a combination side of transparency and an echo in the 5th scan optical system.
[0034] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0035] The operation effect of this scan optical system is explained. Since two operations of transparency and an echo are performed in respect of the same, the number of pages which constitutes image formation optical system can be reduced, and image formation optical system can be made simple and small. In this case, if reflex action is considered as a total reflection operation, in addition, it is desirable. If not total reflection but an echo with a reflective film tends to perform an echo in a combination side, it is necessary to form a reflective film for reflectors in a transparency field for transparency sides, and another distant location. For this reason, problems, like that optical system is enlarged and generating aberration increases arise. Moreover, since it is necessary to produce a reflective film, cost rises.
[0036] Condensing optical system to which the 8th scan optical system of this invention makes light from the light source and said light source abbreviation parallel light, In scan optical system which consists of an optical deflection means to deflect injection light from said condensing optical system, and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed As for said prism member, said scan optical system is characterized by said a part of condensing optical system and including said a part of image formation optical system at least at least including a prism member.
[0037] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0038] The operation effect of this scan optical system is explained. Since a part of condensing optical system and a part of image formation optical system can be constituted from one optical element, components mark which constitute scan optical system are reducible. Consequently, a positioning activity at the time of an assembly for obtaining desired engine performance becomes easy, and it can low-cost-ize.
[0039] 9th scan optical system of this invention is characterized by said condensing optical system and said image formation optical system consisting of one prism member in the 8th scan optical system.
[0040] this scan optical system -- after-mentioned example 1- 3 and 6 correspond.
[0041] If the operation effect of this scan optical system is explained, an effect of the 8th scan optical system will become larger.
[0042] Condensing optical system to which the 10th scan optical system of this invention makes light from the light source and said light source abbreviation parallel light, In scan optical system of the 1st, 5, or 8 which consists of an optical deflection means to deflect injection light from said condensing optical system, and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed It is characterized by reflecting 3 times or more in the sum total of said condensing optical system and said image formation optical system.
[0043] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0044] The operation effect of this scan optical system is explained. an effect of folding becomes large by making it reflect a total of 3 times or more, and an effect of a miniaturization of the whole scan optical system can be enlarged more.
[0045] 11th scan optical system of this invention is characterized by having said a part of

condensing optical system and the combination side of transparency and an echo of said prism member which includes said a part of image formation optical system at least at least in the 8th scan optical system.

[0046] As for this scan optical system, the after-mentioned examples 1-6 correspond.

[0047] The operation effect of this scan optical system is explained. Since two operations of transparency and an echo are performed in respect of the same, the number of pages which constitutes scan optical system can be reduced, and optical system can be made simple and small. In this case, if reflex action is considered as a total reflection operation, in addition, it is desirable. If not total reflection but an echo with a reflective film tends to perform an echo in a combination side, it is necessary to form a reflective film for reflectors in a transparency field for transparency sides, and another distant location. For this reason, problems, like that optical system is enlarged and generating aberration increases arise. Moreover, since it is necessary to produce a reflective film, cost rises.

[0048] 12th scan optical system of this invention is characterized by having said a part of condensing optical system and the combination side where said prism member which includes said a part of image formation optical system at least performs three optical operations of two transparency operations and one reflex action at least in the 11th scan optical system.

[0049] As for this scan optical system, the after-mentioned examples 1-6 correspond.

[0050] If the operation effect of this scan optical system is explained, an effect of the 11th scan optical system will become still larger. Moreover, if a field facing an optical deflection means of a prism member is made into this combination side, the operation effect of the 5th scan optical system can be acquired.

[0051] The 13th scan optical system of this invention is set at least in the 8th scan optical system to a part and said prism member which includes said a part of image formation optical system at least of said condensing optical system. A portion of said condensing optical system included in said prism member at least nonrotation which has plane of incidence to said prism member, and optical power, and carried out eccentricity to a shaft top chief ray -- a plane of symmetry reflector -- A portion of said image formation optical system included in said prism member including the 3rd page of injection sides from a prism member nonrotation which has re-plane of incidence to said prism member, and optical power, and carried out eccentricity to a shaft top chief ray at least -- it is characterized by including the 3rd page of a plane of symmetry reflector and re-injection sides from a prism member.

[0052] As for this scan optical system, the after-mentioned examples 1-6 correspond.

[0053] The operation effect of this scan optical system is explained. Since a reflector which has optical power has a lens operation and a deflection operation, its effect which miniaturizes optical system is large. Since both condensing optical system and image formation optical system can be miniaturized in the case of this scan optical system, the whole scan optical system can be miniaturized.

[0054] However, in optical system which used a reflector which has optical power and carried out eccentricity to a shaft top chief ray, in order that a beam of light may carry out incidence aslant to a reflector which carried out eccentricity, comatic aberration by eccentricity, astigmatism, etc. occur also by the axial Uemitsu line. This eccentric aberration can be amended by making this reflector into a revolution unsymmetrical side.

[0055] Moreover, although a problem that linear scan nature is not securable arises when making a reflector which carried out eccentricity carry out incidence of the light deflected by optical deflection means in scan optical system generally, linear scan nature is securable by making a reflector of image formation optical system into a reflector symmetrical with nonrotation. Moreover, image formation optical system can be used as a two-dimensional f arc sine theta lens or a two-dimensional ftheta lens by using a revolution unsymmetrical side, and a uniform scan can be carried out for a scan layer-ed by scan optical system.

[0056] Moreover, a beam plastic surgery operation over the light source which has an ellipse-like cross-section configuration in a portion of condensing optical system included in a prism member like LD by using a reflector symmetrical with nonrotation can be given, or a field failure amendment function can be given.

[0057] Generally, since a reflector must control an eccentric error severely from a refracting interface, assembly tuning becomes serious. However, if a reflector is constituted as 1st page of a prism member, tuning of this reflector is reducible.
[0058] Moreover, since a beam of light which carries out incidence to a portion of image formation optical system of a prism member from a deflection means is refracted by plane of incidence of a prism member, it can set up low the incident ray high of an axial outdoor daylight line to subsequent fields. Therefore, while being able to make optical system small, a bigger field angle is realizable. Moreover, since the subordination beam-of-light high of an axial outdoor daylight line becomes low, generating of comatic aberration etc. can also be controlled.
[0059] It is characterized by having only one plane of symmetry concerning [on scan optical system of the 1st, 5, or 8, and / nonrotation plane of symmetry of said image formation optical system] a configuration in the 14th scan optical system of this invention.
[0060] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0061] If the operation effect of this scan optical system is explained, fabrication nature can be raised by having the plane of symmetry about a configuration.
[0062] 15th scan optical system of this invention is characterized by including nonrotation plane of symmetry in which said condensing optical system has only one plane of symmetry about a configuration in scan optical system of the 1st, 5, or 8.
[0063] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0064] if the operation effect of this scan optical system is explained -- a revolution -- the operation effect of an unsymmetrical field is the same as the 13th scan optical system. The operation effect by having one plane of symmetry about a configuration is the same as the 14th scan optical system. Condensing optical system has the above operation effect.
[0065] 16th scan optical system of this invention is characterized by being the free sculptured surface in which nonrotation plane of symmetry of said image formation optical system has only one plane of symmetry about a configuration in scan optical system of the 1st, 5, or 8.
[0066] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0067] The operation effect of this scan optical system is explained. A free sculptured surface used by this invention is defined by the following formulas (a). In addition, the Z-axis of the definition type turns into a shaft of a free sculptured surface.
[0068]

$$Z = cr^2 / [1 + \sqrt{\{1 - (1+k) c^2 r^2\}}] + \sum_{j=2}^{66} C_j X^m Y^n \quad \cdots (a)$$

Here, the 1st term of the (a) type is a spherical-surface term, and the 2nd term is a free sculptured surface term.
[0069] Inside of a spherical-surface term, curvature k of c:top-most vertices: Conic constant (cone constant)
r=root (X2+Y2)
It comes out.
[0070] Free sculptured surface term,

$$\sum_{j=2}^{66} C_j X^m Y^n$$

$$\begin{aligned}
&= C_2 X + C_3 Y \\
&+ C_4 X^2 + C_5 XY + C_6 Y^2 \\
&+ C_7 X^3 + C_8 X^2 Y + C_9 XY^2 + C_{10} Y^3 \\
&+ C_{11} X^4 + C_{12} X^3 Y + C_{13} X^2 Y^2 + C_{14} XY^3 + C_{15} Y^4 \\
&+ C_{16} X^5 + C_{17} X^4 Y + C_{18} X^3 Y^2 + C_{19} X^2 Y^3 + C_{20} XY^4 \\
&\qquad + C_{21} Y^5 \\
&+ C_{22} X^6 + C_{23} X^5 Y + C_{24} X^4 Y^2 + C_{25} X^3 Y^3 + C_{26} X^2 Y^4 \\
&\qquad + C_{27} XY^5 + C_{28} Y^6 \\
&+ C_{29} X^7 + C_{30} X^6 Y + C_{31} X^5 Y^2 + C_{32} X^4 Y^3 + C_{33} X^3 Y^4 \\
&\qquad + C_{34} X^2 Y^5 + C_{35} XY^6 + C_{36} Y^7 \\
&\qquad \cdots\cdots
\end{aligned}$$

However, Cj (j is two or more integers) is a coefficient.
[0071] Generally, the above-mentioned free sculptured surface turns into a Y-Z side and a free sculptured surface where only one parallel plane of symmetry exists by setting all of the oddth term of X to 0 by this invention, although a X-Z side and a Y-Z side do not have plane of symmetry. for example, the above-mentioned definition type (a) -- setting -- C2, C5, C7, C9, and C12, C14, C16, C18, C20, C23, C25, C27, C29, C31, C33 and C35 -- it is possible by setting a coefficient of each term of ... to 0.
[0072] Moreover, it becomes a X-Z side and the free sculptured surface where only one parallel plane of symmetry exists by setting all odd number terms of Y to 0. for example, the above-mentioned definition type -- setting -- C3, C5, C8, and C10, C12, C14, C17, C19, C21, C23, C25, C27, C30, C32, C34 and C36 -- it is possible by setting a coefficient of each term of ... to 0.
[0073] By making the eccentricity of either of the above-mentioned plane of symmetry carry out in the direction of plane of symmetry of Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. to plane of symmetry, fabrication nature can also be raised simultaneously, amending effectively aberration symmetrical with nonrotation generated with eccentricity.
[0074] In addition, a definition type of a free sculptured surface is good also as other definition types, such as a Zernike polynomial.
[0075] 17th scan optical system of this invention is characterized by said optical deflection means being a two-dimensional optical deflection means which carries out a two-dimensional deflection with one optical deflection means in scan optical system of the 1st, 5, or 8.
[0076] As for this scan optical system, the after-mentioned examples 1-5 correspond.
[0077] The operation effect of this scan optical system is explained. In order to make area of an optical deflection means small, it is necessary to arrange a deflection means near the entrance pupil of image formation optical system. When performing a two-dimensional scan using two 1-dimensional optical deflection means, in order to make magnitude of an optical deflection means small, it is necessary to make conjugate two 1-dimensional optical deflection means, or to make small a gap of two 1-dimensional optical deflection means, and troubles, like optical system's being complicated and a constraint about a layout of optical system to enlarge increase arise. If a two-dimensional deflection is carried out with one optical deflection means, it is easy to carry out a layout of optical system, and optical system can be made small and simple.
[0078] 18th scan optical system of this invention is characterized by a deflection angle by said optical deflection means changing in the shape of a sine wave in scan optical system of the 1st, 5, or 8.
[0079] As for this scan optical system, the after-mentioned examples 1, 2, 4-6 correspond (if electric image distortion amendment is performed, an example 3 also corresponds.).
[0080] The operation effect of this scan optical system is explained. For example, when a micro machine scanner manufactured using micro machine technology which is indicated by JP,10-

20226,A has only the 1st page of a reflective mirror and it carries out rapid scanning, this reflective mirror vibrates in the shape of a sine wave, and carries out the reflective deflection of the light. If such an optical deflection means is used, an optical deflection means can be made into small, low cost, and a low power, and rapid scanning can be carried out. If image formation optical system of scan optical system is used as an f arc sine theta lens at this time, the uniform scan of the scan layer-ed can be carried out.
[0081] 19th scan optical system of this invention is characterized by using 95% or less of amplitude of an optical deflection angle for a scan in the 18th scan optical system in an optical deflection means by which the aforementioned deflection angle changes in the shape of a sine wave.
[0082] As for this scan optical system, the after-mentioned examples 1, 2, 4-6 correspond (if electric image distortion amendment is performed, an example 3 also corresponds.).
[0083] The operation effect of this scan optical system is explained. Hereafter, in the case of reflective mold deflecting system [, such as a polygon mirror and a galvanomirror,], it explains. As shown in drawing 9 (a), when the deflection angle phi from a criteria reflector of a reflector of reflective mold deflecting system (reflective mold deflection means) uses a deflection means which changes in the shape of a sine wave, in order to carry out a uniform scan without electric image distortion amendment, it is necessary to use image formation optical system as an f arc sine theta lens.
[0084] A deflection angle of a reflector presupposes that a scan layer-ed is scanned in a deflection means which changes in the shape of a sine wave using a k times as many deflection angle (**phi0) as amplitude of a deflection angle by amplitude phi0 / k. In order to use image formation optical system as an f arc sine theta lens at this time, it is necessary to fill a degree type (0< k<=1).
[0085] Image quantity y=f and 2(phi0 / k) arcsin {phi/(phi0 / k)}
When a deflection is about **20 degrees, in order to use image formation optical system as an f arc sine theta lens to all of deflection angles, it is necessary to generate distortion of very big plus, and layout of image formation optical system is difficult. Then, if the linearity of phi/(phi0 / k) uses only a good field, it will become easy to use image formation optical system as an f arc sine theta lens.
[0086] If k is made or less into 0.95, it will become a case where the linearity of phi/(phi0 / k) is k= 1, and below a linear medium degree, and it will become easy to use image formation optical system as an f arc sine theta lens. Consequently, optical system can be made simple and small.
[0087] Moreover, as the usual display also has about 17% of blanking period, in scan optical system, all of deflection angles cannot be used from relation of electric processing. In this case, about 95% of amplitude of a deflection angle of a deflection means serves as a maximum.
[0088] As shown in drawing 9 (b), in the case of an optical deflection means of a transparency mold like an acoustooptic deflector AOD, in the above explanation, it should just be considered that 2phi is a deflection angle.
[0089] 20th scan optical system of this invention is characterized by amending electric uniform scan nature in scan optical system of the 1st, 5, or 8.
[0090] This scan optical system may be applied to which example example.
[0091] The operation effect of this scan optical system is explained. When performing a two-dimensional scan especially, if it is going to secure two-dimensional linear scan nature and uniform scan nature by controlling distortion of image formation optical system according to the deflection property of an optical deflection means, optical system will do complicated and enlargement of. Since electric image distortion amendment of linear scan nature turns into two-dimensional amendment on the other hand when carrying out a high-speed two-dimensional scan, amending on real time becomes difficult.
[0092] Then, if it is secured by image formation optical system and secures uniform scan nature by performing electric amendment, linear scan nature can make optical system simple and small, and since electric image distortion amendment turns into amendment to the one scanning line of a main scanning direction, it can respond also to rapid scanning.
[0093] In this case, if it is going to use all the amplitude of a deflection angle that change in the

shape of a sine wave, a difference of a scan speed near the center of an image with a quick scan speed and near the circumference of an image with a slow scan speed will become large too much. Even when performing electric image distortion amendment, it becomes impossible consequently, to amend with a sufficient precision. If about 85% of deflection angle amplitude is used, since amendment of uniform scan nature will become good in about two steps, it is desirable.

[0094] 21st scan optical system of this invention is characterized by a deflection angle by said optical deflection means changing to a linear in scan optical system of the 1st, 5, or 8.

[0095] As for this scan optical system, the after-mentioned example 3 corresponds (if electric image distortion amendment is performed, examples 1, 2, 4-6 also correspond.).

[0096] The operation effect of this scan optical system is explained. Since a rotating polygon (polygon mirror) is carrying out the uniform revolution, an optical deflection angle changes to a linear. If a rotating polygon (polygon mirror) is used as an optical deflection means, a big deflection angle can be secured with an optical deflection means, and a field angle of scan optical system can be enlarged. If image formation optical system of scan optical system is used as ftheta lens at this time, the uniform scan of the scan layer-ed can be carried out.

[0097] In scan optical system of the 1st, 5, or 8, the 22nd scan optical system of this invention has only one plane of symmetry about a configuration, said image formation optical system is carrying out eccentricity only by plane-of-symmetry inboard about the configuration, and said scan optical system is characterized by satisfying a degree type.

[0098]

phi2 < / SUB>theta 1 / phi 1 theta2 <1 ... (1)

Here, it is a single-sided deflection angle of an optical deflection means required for a scan of 2phi2, plane of symmetry, and a scan layer-ed of the direction of the orthotomic surface about a single-sided deflection angle of an optical deflection means required for a scan of a scan layer-ed of theta 1 and the direction of plane of symmetry in a half-field angle of image formation optical system [in / for a half-field angle of image formation optical system in plane-of-symmetry inboard by the side of a scan layer-ed / theta 2 plane of symmetry, and the direction of the orthotomic surface] 2phi1 It carries out.

[0099] a case of a reflective mold deflection means like a polygon mirror and a galvanomirror -- a single-sided deflection angle of a reflective mirror required for a scan -- phi 1 and phi 2 it is -- it is equivalent to things. A single-sided deflection angle of a reflective mirror side said here is the maximum gap angle from a reflective mirror side corresponding to a center of a scan layer-ed. **phi In this case, a reflective mirror of an optical deflection means does not necessarily sway. When scanning a scan layer-ed using a part of amplitude of a reflective mirror, **phi uses for a scan. Moreover, in the case of an optical deflection means of a transparency mold like an acoustooptic deflector AOD, a single-sided deflection angle is 2phi1 and 2phi2. It corresponds (drawing 9). As for this scan optical system, the after-mentioned examples 1-6 correspond.

[0100] The operation effect of this scan optical system is explained. It explains by case where an optical deflection means of a reflective mold like a polygon mirror and a galvanomirror is used (drawing 9 (a)). When a single-sided deflection angle of a reflective mold optical deflection means is phi (a deflection angle is 2phi), a scan half field angle of image formation optical system sets to theta. At this time, it is pupil scale-factor =2 phi/theta of image formation optical system in an order trace.

[0101] If image formation optical system has only the 1st page of plane of symmetry about a configuration and is carrying out eccentricity only within the plane of symmetry, since the fabrication nature of image formation optical system will improve and cost will also fall, it is desirable. In this case, since plane of symmetry and a perpendicular direction about a configuration tend to secure an extensive field angle, they are good to carry out this direction in a scanning direction of 1-dimensional scan optical system, or the direction where a scan field angle of two-dimensional scan optical system is large. Since field inboard to which eccentricity of the image formation optical system is carried out at this time needs to constitute optical system so that a field and a field which carried out eccentricity may not interfere, it becomes difficult to constitute image formation optical system.

[0102] Then, it becomes easy to constitute image formation optical system to have made smaller than a pupil scale factor of plane of symmetry and a perpendicular direction a pupil scale factor of a direction (plane-of-symmetry inboard about a configuration of image formation optical system) to which eccentricity of the image formation optical system is carried out, and to have made small an angle of divergence of the flux of light within image formation optical system.
[0103] That is, it is desirable to satisfy a degree type.
[0104]
Pupil scale-factor =(2phi2 / theta 2)/within the pupil scale factor / plane of symmetry in 1> plane of symmetry, and the orthotomic surface (2phi1 / theta 1)
= phi 2 theta 1 / phi 1 When making the direction of vertical scanning, and plane of symmetry and a perpendicular direction into a main scanning direction for the direction of plane of symmetry about a configuration of theta2 image-formation optical system, in order to make equal resolution of image formation optical system of a main scanning direction in a scan layer, and the direction of vertical scanning, the need of making a size of the direction of vertical scanning of an optical deflection means larger than a size of a main scanning direction arises. Since the size of a needed [rapid scanning] main scanning direction is small when performing a two-dimensional scan, it becomes easy to respond to rapid scanning.
[0105] 23rd scan optical system of this invention is characterized by satisfying the following conditional expression in the 22nd scan optical system.
[0106]
NA2/NA 1> 1 ... (2)
Here, numerical aperture of the flux of light from the light source in plane of symmetry and a perpendicular direction of the flux of light which carries out incidence from the light source in plane-of-symmetry inboard about a configuration to condensing optical system concerning NA2 and a configuration in numerical aperture to condensing optical system which carries out incidence is set to NA1.
[0107] As for this scan optical system, the after-mentioned examples 1-6 correspond.
[0108] The operation effect of this scan optical system is explained. When making the direction of vertical scanning, and plane of symmetry and a perpendicular direction into a main scanning direction for the direction of plane of symmetry about a configuration of image formation optical system, in order to make equal resolution of image formation optical system in a main scanning direction and the direction of vertical scanning of a scan layer, the need of making a size of the direction of vertical scanning of an optical deflection means larger than a size of a main scanning direction arises.
[0109] In order for light which emitted the light source to become the above-mentioned configuration in a scan means, a configuration of condensing optical system becomes [a direction with which were satisfied of conditional expression (2)] easy.
[0110]
[Embodiment of the Invention] Below, an example 6 is explained with reference to a drawing from the example 1 of the scan optical system of this invention.
[0111] The following explanation explains a main scanning direction and the direction of Y for the direction of X as a direction of vertical scanning.
[0112] Although the postscript of the configuration parameter in a counterlight trace of each example is carried out, as shown in drawing 1 , it is a counterlight trace, and it passes along the center of the scan layer-ed whose shaft top chief ray 1 is not illustrated vertically, and the beam of light which reaches the center of the light source 11 through the optical deflection means 12 defines the configuration parameter of each of that example.
[0113] and the 1st returned to the non-eccentricity condition in the counterlight trace -- page 4T (eccentricity is actually carried out in the direction of Y.) The direction which goes to page 4T is made into the Z-axis positive direction. the direction which meets the shaft top chief ray 1 -- Z shaft orientations -- carrying out -- the 1st of a scan layer-ed to the optical system 10 -- A flat surface including this Z-axis and a scan-layer-ed center is made into a Y-Z flat surface (field of drawing 1), it intersects perpendicularly with a Y-Z flat surface through a zero, the direction which goes in the direction of the reverse side from this side of space is made into the

X-axis positive direction, and a Y-axis is set as the X-axis, the Z-axis, and the shaft that constitutes Cartesian coordinates. These system of coordinates are illustrated in drawing 1 . About drawing 4 which shows other examples – drawing 8 , the graphic display of these system of coordinates is excluded.

[0114] About the eccentric side, the eccentricity (they are X, Y, and Z about X shaft orientations, Y shaft orientations, and Z shaft orientations, respectively) of the plane peak of the field and the angle of inclination (respectively alpha, beta, gamma (degree)) consisting mainly of the X-axis of the medial axis (about a free sculptured surface, it is the Z-axis of the aforementioned (a) formula) of the field, a Y-axis, and each Z-axis are given from the zero of the above-mentioned system of coordinates. In addition, in positive [of alpha and beta], positive [of gamma] means a clockwise rotation for a counterclockwise rotation to the positive direction of the Z-axis in that case to the positive direction of each shaft.

[0115] In the examples 1-6, eccentricity of each side is performed in this Y-Z flat surface, and the only plane of symmetry of each revolution unsymmetrical free sculptured surface is made into the Y-Z side.

[0116] Moreover, in the optical operating surface which constitutes the optical system of each example, when a specific field (a virtual side is included.) and the field following it constitute coaxial optical system, the spacing is given, in addition the refractive index of a medium and the Abbe number are given according to the using-commonly method.

[0117] Moreover, the aforementioned (a) formula defines the configuration of the field of a free sculptured surface where it is used by this invention, and the Z-axis of the definition type turns into a shaft of a free sculptured surface.

[0118] moreover -- DOE (diffracted-light study element) -- as a design method -- Sweatt -- law (super-high refractive-index method) was used (wcSweatt, "Mathematical equivalence between a holographic optical element and an ultra-high index lens", J.Opt.Soc.Am, Vol.69, and No.3 (1979)), and it was referred to as criteria wavelength =587.56nm (d line), and was referred to as refractive-index =1001 of the super-high refractive-index lens in the criteria wavelength, and Abbe number =-3.45.

[0119] In addition, the term about the free sculptured surface where data is not indicated is 0. About the refractive index, the thing to d line (wavelength of 587.56nm) is written. The unit of mm and an angle of the unit of length is **.

[0120] Moreover, there is a Zernike polynomial given by the following (b) formulas as a definition type which is everything but a free sculptured surface. The following formulas define the configuration of this field. The Z-axis of the definition type turns into a shaft of a Zernike polynomial. The definition of a revolution unsymmetrical side is defined by the polar coordinate of the height of the shaft of Z to X-Y page, and A is the distance from the Z-axis within a X-Y side, R is the azimuth of the circumference of the Z-axis, and it can be expressed with the angle of rotation measured from the Z-axis.

[0121]

x=Rxcos (A) y=Rxsin (A) Z=D2 + D3 Rcos(A)+D4 Rsin (A) + D five R2 cos(2A)+D6+(R2-1) D seven R2 sin (2A) + D8 R3 cos (3A)+D9 cos (3R3-2R) (A) + D10(3R3-2R) sin(A)+D11R3 sin (3A) + D12R4cos(4A)+D13(four R4-3R2) cos (2A) + D14(six R4-6R2+1)+D15(four R4-3R2) sin (2A) +D16R4 sin (4A) + D17R5cos (5A)+D18(five R5-4R3) cos (3A) + D19(10R5-12R3+3R) cos(A) + D20(10R5-12R3+3R) sin(A) + D21(five R5-4R3) sin (3A)+D22R5 sin (5A) +D23R6cos(6A)+D24(six R6-5R4) cos (4A) +D25(15R6-20R4+6R2) cos (2A) +D26 (20R6-30R4+12R2-1) + D27(15R6-20R4+6R2) sin (2A) +D28(six R6-5R4) sin (4A)+D29R6sin (6A) .... (b)

In addition, in order to design as optical system symmetrical with X shaft orientations, D4, D5, D6, D100, D11, D12, D13, D14, D20 and D21, and D22 -- are used.

[0122] The following definition type (c) is held as an example of other fields.

[0123] When considering k= 7 (7th term) it develops as an example of Z=sigmasigmaCnmXY, it can express with the following formulas.

[0124]

Z=C2 +C3 y+C4 |x| +C5 y2 +C6 y|x|+C7 x2 +C8 y3 +C9 y2 |x|+C10yx2 +C11|x3 | +C12y4 +C13y3 |x|+C14y2 x2 +C15y|x3 |+C16x4 +C17y5 +C18y4 |x|+C19y3 x2 +C20y2 |x3 | +C21yx4 +C22|x5 | +

C23y6+C24y5 |x|+C25y4 x2+C26y3 |x3 | + C27y2 x4+C28 y|x5 |+C 29x6 +C30y7+C31y6 |x|+C32y5 x2+C33y4 |x3 | +C34y3 x4+C35y2 |x5 |+C36yx6+C37|x7 | ... (c)
In addition, although the field configuration is expressed in the example of this invention in the free sculptured surface which used the aforementioned (a) formula, even if it uses the above-mentioned (b) formula and the (c) type, it cannot be overemphasized that the same operation effect can be acquired.

[0125] (Example 1) A Y-Z plan (cross section within the direction side of vertical scanning) including the optical axis of the scan optical system of this example is shown in drawing 1 . It is 42 degrees in 54 degrees of horizontal angles of view of this scan optical system, and vertical field angle, and the magnitude of an optical deflection means is phi1mm.

[0126] With the light source intensity modulation means which is not illustrated, the configuration of this scan optical system 10 carries out intensity modulation of the light source 11 according to a video signal, and it is performing the two-dimensional scan (raster scan) according to a video signal, and image formation of it is carried out to a scan layer-ed with a location [ahead of image formation optical system] of 1m, and it carries out the two-dimensional scan of the scan layer-ed.

[0127] follow light line tracking which reaches the image surface (scan layer-ed) which does not illustrate the optical path of this scan optical system 10 from the light source 11 -- it is -- the 1st -- transparency side 1T and 1st reflector 1R and the 2nd -- light source light is made abbreviation parallel by the condensing optical system which consists of transparency side 2T. The reflective deflection of the light source light made into abbreviation parallel light is carried out with the two-dimensional scanner 12. the light by which the reflective deflection was carried out -- the 3rd -- transparency side 3T and 2nd reflector 2R, 3rd reflector (total reflection) 3R, and the 4th -- image formation is carried out to a scan layer-ed according to the image formation optical system which consists of transparency side 4T, and the two-dimensional scan of the scan layer-ed is carried out.

[0128] LED, LD, etc. can be used as the light source 11. What is necessary is just to make it shown in drawing 2 , when carrying out color display using two or more sources of the homogeneous light. the plane of composition of the light source prism 21 which consists of a rectangular prism the dichroic mirror 24 made to reflect short wave Nagamitsu, for example, light with a wavelength of 500nm or less, in drawing 2 , and the light source prism 22 -- coating -- a long wave -- the plane of composition of the light source prism 22 which consists of a rectangular prism, and the light source prism 23 is coated with the dichroic mirror 25 made to reflect Nagamitsu, for example, light 600nm or more. And illuminant-B11B, R light source 11R, and G light source 11G In each wavelength of the light source prism 21, the light source prism 22, and the light source prism 23, the image point of a scan layer-ed and a location [****] were pasted, respectively, and the effect of the chromatic aberration of scan optical system is removed.

[0129] By this configuration, RGB light can be led to the scan optical system 10, and color display can be performed. At this time, intensity modulation of each of RGB light is carried out for every pixel with the modulator for RGB on the strength which is not illustrated based on a video signal.

[0130] Although some things can be used as a scan means (two-dimensional scanner) 12, since the micro machine scanner manufactured using micro machine technology which is indicated by JP,10-20226,A has advantages, such as small and a low power, it is the optimal as an object for small optical system.

[0131] in this case, electromagnetism -- the micro machine scanner of various actuation methods, such as an actuation method, an electrostatic actuation method, and a piezoelectric-device actuation method, can be used. The plan of one example of a two-dimensional micro machine scanner is shown in drawing 3 . In this example, the mirror section 34 is connected with the medium frame 32 with the torsion bar spring 33 prolonged in Y shaft orientations, that medium frame 32 is connected with an outer frame 30 with the torsion bar spring 31 prolonged in X shaft orientations, and it is made to carry out a vertical scanning (the direction scan of Y) by the splash around a torsion bar spring 33 with the splash around a horizontal scanning (the

direction scan of X), and a torsion bar spring 31.
[0132] To generally use a rotating polygon (polygon mirror) with a two or more pages reflector as a scanner, optical system needs to have a field failure amendment function. However, since it does not generate on the structure of a scanner, optical system does not need to have a field failure amendment function, and the failure by the field from which only 34 has the 1st page of a reflector, and a micro machine scanner as shown in drawing 3 poses a problem in it can simplify the configuration of optical system.
[0133] In this case, incident angle thetas of a shaft top chief ray to the datum level of a reflector It is desirable to satisfy a degree type.
[0134] theta -- since the area of a reflector will become large even when carrying out the reflective deflection of the same flux of light if s<=45-degree 45 degrees of the maximum of this condition are exceeded, it becomes difficult to secure a large deflection angle and high scan frequency. In this example, it is thetas=20 degree.
[0135] In addition, although the single-sided scan of only the outward trip of the deflection angle of a scanner which carries out a both-way oscillation at the shape of a sine wave, the both-way scan of both an outward trip and a return trip, or whichever is sufficient, since scan frequency of a scan means will be made in half if a both-way scan is performed, it is easy to respond to rapid scanning.
[0136] The advantage of the scan optical system 10 of this example is explained. Since condensing optical system and image formation optical system are constituted from one of the prism member 10, compared with the example of precedence, components mark are reduced substantially, it miniaturizes and-izing of the optical system can be carried out [low cost]. Moreover, since there are few components mark, positioning activities can be reduced, and it also becomes easy to secure the engine performance at the time of a fabrication.
[0137] Moreover, since the echo, and the 2 times echo and the 1-time echo with a scanner by image formation optical system are reflected once a total of 4 times by condensing optical system, optical system can be miniaturized according to the collapsible effect. Moreover, since a reflector has the main power of the scan optical system 10, there is little generating of chromatic aberration, and even when LD is made into the light source, there is little change of the optical-character ability of the scan optical system 10 by the wavelength variation of LD. Moreover, the combination with 2nd reflector 2r with a convex power operation and a concave power operation of 3rd reflector (total reflection side) 3R has amended the curvature of field in the scan field angle whole region.
[0138] Moreover, since there are combination side 2T (3T, 3R) which serve both as reflex action and a transparency operation, the number of pages which constitutes optical system can be reduced, and condensing optical system and image formation optical system can be miniaturized. Having made this field the concave surface configuration to the deflection means 12 tends to carry out reflex action to a total reflection operation.
[0139] Moreover, generally reservation of linear scan nature poses a problem by reflective mold scan optical system about linear scan nature and uniform scan nature. the revolution whose reflector amends eccentric aberration in this example -- since it is an unsymmetrical configuration, two-dimensional linear scan nature has been secured.
[0140] The deflection angle of the scanning mirror 12 required for a two-dimensional scan Since image formation optical system has an f arc sine theta lens property to about 65% of the scanning mirror which are phix=**7.95 degree and phiy=**3.20 degree and vibrates in the shape of a sine wave in this case A two-dimensional linear scan and a uniform scan can be performed (mirror deflection angle phix=**7.95 degree which needs for the scan of the direction of X 65% of the amplitude which is scanning mirror deflection angle phix=**12.2 degree of the direction of X.). Mirror deflection angle phiy=**3.20 degree which needs 65% of the scanning mirror deflection angle phiy=**4.93 degree amplitude of the direction of Y for the scan of the direction of Y. .
[0141] When the deflection angle of the scanning mirror 12 is this example degree, in order to use image formation optical system as an f arc sine theta lens, it is necessary to generate the distortion of plus in image formation optical system. Distortion can be effectively amended by making field 4T by the side of a scan layer-ed into the independent operating surface of only a

transparency operation most like this example in the field which has the optical power of image formation optical system. Moreover, reservation of a field angle also becomes easy.
[0142] In addition, if electric image distortion amendment (amendment of uniform scan nature) which changes into a uniform scan image the non-uniform scan image formed of image formation optical system is performed, all the amplitude of the scanning mirror 12 which vibrates in the shape of a sine wave can also be used, and a scanning mirror deflection angle can also use the scanner which changes to a linear.
[0143] Moreover, the beam plastic surgery function is given to condensing optical system. When considering 12 asphi1mm of deflection means, for the light source condensing optical system side NA, the direction of X is [0.16 and the direction of Y] 0.19.
[0144] Next, although the two-dimensional image will be formed here by carrying out the two-dimensional scan of the punctiform light source 11 if deformation of this example is described, you may make it scan the linear 1-dimensional array light source.
[0145] Moreover, although designed as a size of the direction of size =Y of the direction of X of a scanner here, it is good also as a size of the direction of size !=Y of the direction of X of a scanner 12 because of making equal resolution of the direction of X by the side of a scan layer-ed, and resolution of the direction of Y etc.
[0146] (Example 2) The same drawing as drawing 1 of the scan optical system of this example is shown in drawing 4 . It is 42 degrees in 54 degrees of horizontal angles of view of this scan optical system, and vertical field angle.
[0147] The configuration of this scan optical system 10 is the same as that of an example 1, and with the light source intensity modulation means which is not illustrated, according to a video signal, intensity modulation of the light source 11 is carried out, it is performing the two-dimensional scan (raster scan) according to a video signal, and it carries out [image formation of it is carried out to a scan layer-ed with a location / ahead of image formation optical system / of 1m, and] the two-dimensional scan of the scan layer-ed.
[0148] follow light line tracking which reaches the image surface (scan layer-ed) which does not illustrate the optical path of this scan optical system 10 from the light source 11 -- it is -- the 1st -- transparency side 1T and 1st reflector 1R and the 2nd -- light source light is made abbreviation parallel by the condensing optical system which consists of transparency side 2T. The reflective deflection of the light source light made into abbreviation parallel light is carried out with the two-dimensional scanner 12. the light by which the reflective deflection was carried out -- the 3rd -- transparency side 3T and 2nd reflector 2R, 3rd reflector (total reflection) 3R, and the 4th -- image formation is carried out to a scan layer-ed according to the image formation optical system which consists of transparency side 4T, and the two-dimensional scan of the scan layer-ed is carried out.
[0149] This example is the type which raised the f arc sine theta lens property from the example 1. The direction of X and the direction of Y have an f arc sine theta lens property to about 70% of the scanning mirror deflection angle amplitude to the scanning mirror 12 which vibrates in the shape of a sine wave.
[0150] In addition, if distortion is controlled and a lens is added between the prism 10 which is a **** location, and a scan layer-ed etc., an f arc sine theta lens property can be raised further.
[0151] (Example 3) The same drawing as drawing 1 of the scan optical system of this example is shown in drawing 5 . It is 42 degrees in 54 degrees of horizontal angles of view of this scan optical system, and vertical field angle, and the magnitude of an optical deflection means is phi1mm.
[0152] The configuration of this scan optical system 10 is the same as that of examples 1 and 2, and with the light source intensity modulation means which is not illustrated, according to a video signal, intensity modulation of the light source 11 is carried out, it is performing the two-dimensional scan (raster scan) according to a video signal, and it carries out [image formation of it is carried out to a scan layer-ed with a location / ahead of image formation optical system / of 1m, and] the two-dimensional scan of the scan layer-ed.
[0153] follow light line tracking which reaches the image surface (scan layer-ed) which does not illustrate the optical path of this scan optical system 10 from the light source 11 -- it is -- the

1st -- transparency side 1T and 1st reflector 1R and the 2nd -- light source light is made abbreviation parallel by the condensing optical system which consists of transparency side 2T. The reflective deflection of the light source light made into abbreviation parallel light is carried out with the two-dimensional scanner 12. the light by which the reflective deflection was carried out -- the 3rd -- transparency side 3T and 2nd reflector 2R, 3rd reflector (total reflection) 3R, and the 4th -- image formation is carried out to a scan layer-ed according to the image formation optical system which consists of transparency side 4T, and the two-dimensional scan of the scan layer-ed is carried out.
[0154] When a deflection angle uses the deflection means 12 which changes to a linear like a rotating polygon (polygon), this example uses image formation optical system as ftheta lens (two-dimensional ftheta lens about the main scanning direction of the direction of X, and the direction of vertical scanning of the direction of Y) so that a uniform scan can be performed in a scan layer-ed.
[0155] (Example 4) The same drawing as drawing 1 of the scan optical system of this example is shown in drawing 6 . It is 36 degrees in 47 degrees of horizontal angles of view of this scan optical system, and vertical field angle, and the magnitude of an optical deflection means is phi1.1mm.
[0156] The configuration of this scan optical system 10 with the light source intensity modulation means which does not come to arrange DOE (diffracted-light study element)13, and is not illustrated between prism 10 and a scanner 12 in arrangement of examples 1-3 According to a video signal, intensity modulation of the light source 11 is carried out, by performing the two-dimensional scan (raster scan) according to a video signal, image formation is carried out to a scan layer-ed with a location [ahead of image formation optical system] of 1m, and the two-dimensional scan of the scan layer-ed is carried out.
[0157] follow light line tracking which reaches the image surface (scan layer-ed) which does not illustrate the optical path of this scan optical system 10 from the light source 11 -- it is -- the 1st -- light source light is made abbreviation parallel by the condensing optical system which consists of DOE13 which established the diffraction side 14 in the field by the side of transparency side 1T and 1st reflector 1R, and 2nd transparency side 2 T and a scanner 12. The reflective deflection of the light source light made into abbreviation parallel light is carried out with the two-dimensional scanner 12. DOE13 by which the light by which the reflective deflection was carried out established the diffraction side 14 in the field by the side of a scanner 12, and the 3rd -- transparency side 3T and 2nd reflector 2R, 3rd reflector (total reflection) 3R, and the 4th -- image formation is carried out to a scan layer-ed according to the image formation optical system which consists of transparency side 4T, and the two-dimensional scan of the scan layer-ed is carried out.
[0158] This example arranges DOE13 between prism 10 and a scanner 12, and amends the chromatic aberration of scan optical system, and it is follow light line tracking which goes to a scan layer-ed from the light source 11, and is at both times of carrying out incidence to image formation optical system from the time of injecting from condensing optical system and facing to a scanner 12, and a scanner 12, and he is trying to receive an operation of DOE13.
[0159] In addition, when using a micro machine scanner as a two-dimensional scanner 12, you may unite with a scanner 12 using the substrate in which DOE13 was formed, as the protection member and sealing member of a scanner 12 etc.
[0160] (Example 5) The same drawing as drawing 1 of the scan optical system of this example is shown in drawing 7 . In arrangement of examples 1-3, with the light source intensity modulation means which does not come to arrange DOE13 and is not illustrated between the light source 11 and prism 10, the configuration of this scan optical system 10 carries out intensity modulation of the light source 11 according to a video signal, and it is performing the two-dimensional scan (raster scan) according to a video signal, and image formation of it is carried out to a scan layer-ed with a location [ahead of image formation optical system] of 1m, and it carries out the two-dimensional scan of the scan layer-ed.
[0161] DOE13 which the optical path of this scan optical system 10 is follow light line tracking which reaches the image surface (scan layer-ed) which is not illustrated from the light source

11, and established the diffraction side 14 in the field by the side of prism 10, and the 1st -- transparency side 1T and 1st reflector 1R and the 2nd -- light source light is made abbreviation parallel by the condensing optical system which consists of transparency side 2T. The reflective deflection of the light source light made into abbreviation parallel light is carried out with the two-dimensional scanner 12. the light by which the reflective deflection was carried out -- the 3rd -- transparency side 3T and 2nd reflector 2R, 3rd reflector (total reflection) 3R, and the 4th -- image formation is carried out to a scan layer-ed according to the image formation optical system which consists of transparency side 4T, and the two-dimensional scan of the scan layer-ed is carried out.

[0162] This example arranges DOE13 between the light source 11 and prism 10, and amends the chromatic aberration of scan optical system.

[0163] (Example 6) The same drawing as drawing 1 of the scan optical system of this example is shown in drawing 8 . The magnitude of 82 degrees of horizontal angles of view and a scanner of this scan optical system is phi2.6mm 1-dimensional scan optical system.

[0164] the 1st which the configuration of this scan optical system 10 is the same as that of an example 1 and abbreviation, is carrying out intensity modulation of the light source 11 according to a video signal, and performing a 1-dimensional scan to the horizontal direction (the direction of X) according to a video signal with the light source intensity modulation means which is not illustrated, and was returned to the non-eccentricity condition -- image formation is carried out to a scan layer-ed with a front location of 10mm from page 4T, and a 1-dimensional scan layer-ed is scanned.

[0165] follow light line tracking which reaches the image surface (scan layer-ed) which does not illustrate the optical path of this scan optical system 10 from the light source 11 -- it is -- the 1st -- transparency side 1T and 1st reflector 1R and the 2nd -- light source light is made abbreviation parallel by the condensing optical system which consists of transparency side 2T. The reflective deflection of the light source light made into abbreviation parallel light is carried out with the primary scanner 12. the light by which the reflective deflection was carried out -- the 3rd -- transparency side 3T and 2nd reflector 2R, 3rd reflector (total reflection) 3R, and the 4th -- image formation is carried out to a scan layer-ed according to the image formation optical system which consists of transparency side 4T, and a 1-dimensional scan layer-ed is scanned.

[0166] As for this example, in a main scanning direction (the direction of X), a deflection angle has an f arc sine theta lens property to 95% of the deflection angle amplitude of the changing scanner 12 in the shape of a sine wave.

[0167] The configuration parameter (lens data) of the above-mentioned examples 1-6 is shown below. In "FFS" in these tables, a free sculptured surface and "RS" show a reflector, and "DOE" shows a diffraction side. In addition, a scanner is arranged in a drawing side and the light source is arranged in the image surface.

[0168]

The 1st page number of an example Radius of curvature Spacing Eccentricity Refractive index Abbe number body side infinity 1000. 00 1 FFS** Eccentricity (1) 1.5254 56.3 2 FFS** (RS) Eccentricity (2) 1.5254 56.3 3 FFS** (RS) Eccentricity (3) 1.5254 56.3 4 FFS** Eccentricity (2) 5 infinity (drawing side) Eccentricity (4) 6FFS** Eccentricity (2) 1.5254 56.37 FFS** (RS) Eccentricity (5) 1.525456.3 8 FFS** eccentricity (6) Image Field infinity Eccentricity (7) FFS**C 4-2.5779x10-2 C6 -1.2030x10-1 C8 -1.1075x10-2C 10-1.8153x10-2 C 112.5232x10-4 C13 7.6132x10-3C15 3.4561x10-3 C17 1.9873x10-4 C19 2.2454x10-4C 216.3462x10-4 C22 1.9509x10-6 C24-1.1858x10-4C26-2.2337x10-4C 28-1.0408x10-4 FFS**C4 7.7922x10-4 C6 7.7495x10-3 C8 3.7699x10-3C10 - 2.3003X10-3 C11 3.8795x10-4 C13 2.1619x10-3C15 2.1746x10-4 C17 3.0215x10-4 C19 4.7146x10-4C21 5.4788x10-5 C 22-2.2446x10-6 C24 6.4487x10-5C26 6.0274x10-5 C28 7.6776x10-6 FFS**C4 -2.2371x10-2C6 1.1690x10-2 C8 7.2963x10-4C10 6.5994x10-4 C11 7.9455x10-4 C13 1.1221x10-3C15 - 1.4706X10-5 C17 - 9.7208X10-4 C19 - 6.3757X10-4C 21-3.9919X10-5 C 22-1.0684X10-4 C24 3.3217X10-4C26 1.1244X10-4 C 28-2.2822X10-6 FFS**C4 3.3846x10-2 C6 2.9857x10-2 C8 -9.7283x10-3C10 - 5.0879X10-3 C11 - 2.5332X10-3C13-4.6775X10-4C 15-1.1206X10-3 C17 2.2389X10-3 C19 1.5076X10-3C 21-2.6497X10-4 C22 8.4446x10-4 C24 1.6456x10-3C26 4.9022x10-4 C 28-

2.7959x10-5 FFS**C4 -5.0621x10-1C6 -1.9566x10-1 C8-2.5991x10-1C 10-8.7768x10-3 </SUP> C11 3.1809x10-1 C13 4.2980x10-1C15 2.6434x10-2 Eccentricity (1) X 0.00 Y -1.50 Z 0.00alpha 0.00 beta 0.00 gamma 0.00 Eccentricity (2) X 0.00 Y 0.62 Z 4.94alpha -45.15 beta 0.00 gamma 0.00 Eccentricity (3) X 0.00 Y 2.80 Z 2.00alpha -73.15 beta 0.00 gamma 0.00 Eccentricity (4) X 0.00 Y -1.00 Z 5.66alpha -52.18 beta 0.00 gamma 0.00 Eccentricity (5) X 0.00 Y 2.66 Z 1.68alpha -66.23 beta 0.00 gamma 0.00 Eccentricity (6) X 0.00 Y -3.05 Z 0.58alpha -79.91 beta 0.00 gamma 0.00 eccentricity (7) X 0.00 Y -3.98 Z 0.78alpha -100.29 beta 0.00 gamma 0.00 .

[0169]

The 2nd page number of an example Radius of curvature Spacing Eccentricity Refractive index Abbe number body side infinity 1000. 00 1 FFS** Eccentricity (1) 1.5254 56.3 2 FFS** (RS) Eccentricity (2) 1.5254 56.3 3 FFS** (RS) Eccentricity (3) 1.5254 56.3 4 FFS** Eccentricity (2) 5 infinity (drawing side) Eccentricity (4) 6FFS** Eccentricity (2) 1.5254 56.37 FFS** (RS) Eccentricity (5) 1.525456.3 8 FFS** eccentricity (6) Image Field infinity Eccentricity (7) FFS**C 41.2830x10-2 C6 -1.0765x10-1 C8 -6.8597x10-3C 10-7.3302x10-3 C 116.8784x10-5 C13 2.0958x10-3C15 4.2746x10-3 C 17-1.4056x10-5 C19 2.1878x10-4C 21-5.6130x10-4 C22 1.2335x10-6 C24-8.3175x10-6C 26-7.0819x10-5 C28 3.5824x10-5 FFS**C4 -1.2602x10-3 C6 6.5870x10-3 C8 8.6539x10-4C10 - 1.4889X10-3 C11 9.7681x10-5 C13 6.7863x10-4C15 2.6351x10-5 C 17-7.9227x10-6 C19 1.2881x10-4C21 4.1327x10-5 C 22-1.3352x10-6 C24-2.8331x10-6C26 1.2199x10-5 C28 5.7971x10-6 FFS**C4 -1.9853x10-2C6 1.2833x10-2 C8 -5.2848X10-4C10 3.7366X10-4 C11 2.2434x10-4 C13 6.4856x10-4C15 1.9609x10-6 C17 2.1708x10-5 C19 - 3.0213X10-4C 21-1.6660X10-5 C 22-3.2798X10-5 C24-2.4481X10-6C26 4.3731X10-5 C 28-3.4736X10-6 FFS**C4 3.5143x10-2 C6 2.9244x10-2 C8 -1.0733x10-2C 10-4.6492x10-3 C11-3.7851x10-3C13-4.4587x10-3C 15-1.1223x10-3 C 17-1.5160x10-3 C19-1.2923x10-3C 21-3.0248x10-4 C 22-4.5680x10-4 C24-1.2579x10-4C26-1.7631x10-4C 28-3.7567x10-5 FFS**C4 -4.7149x10-1 C6 -1.8302x10-1 C8 -1.5918x10-1C 10-1.0259x10-2 C11 1.8967x10-1 C13 2.7011x10-1C15 2.3839x10-2 Eccentricity (1) X 0.00 Y -1.50 Z 0.00alpha 0.00 beta 0.00 gamma 0.00 Eccentricity (2) X 0.00 Y 0.91 Z 4.98alpha -46.60beta 0.00 gamma 0.00 Eccentricity (3) X 0.00 Y 2.80 Z 1.83alpha -73.91 beta 0.00 gamma 0.00 Eccentricity (4) X 0.00 Y -1.00 Z 5.62alpha -50.77 beta 0.00 gamma 0.00 Eccentricity (5) X 0.00 Y 2.64 Z 1.67alpha -65.89 beta 0.00 gamma 0.00 Eccentricity (6) X 0.00 Y -3.05 Z 0.60alpha -79.70 beta 0.00 gamma 0.00 eccentricity (7) X 0.00 Y -3.96 Z 0.83alpha -98.37 beta 0.00 gamma 0.00 .

[0170]

The 3rd page number of an example Radius of curvature Spacing Eccentricity Refractive index Abbe number body side infinity 1000. 00 1 FFS** Eccentricity (1) 1.5254 56.3 2 FFS** (RS) Eccentricity (2) 1.5254 56.3 3 FFS** (RS) Eccentricity (3) 1.5254 56.34 FFS** eccentricity (2) 5 infinity (drawing side) Eccentricity (4) 6FFS** Eccentricity (2) 1.525456.3 7 FFS** (RS) Eccentricity (5) 1.525456.3 8 FFS** eccentricity (6) Image Field infinity Eccentricity (7) FFS**C 42.0048x10-3 C6 -6.5253x10-2 C8 -2.1891x10-3C10-5.2349x10-2C11 4.3385x10-4 C13 2.5336x10-3C15 8.2781x10-3 C 17-2.3112x10-5 C19-4.8161x10-4C21 3.6053x10-3 C 22-5.0443x10-6 C24-1.0024x10-5C26 4.9410x10-5 C 28-8.4784x10-4 FFS**C4 9.3276x10-3 C6 1.2305x10-2 C8 3.3701x10-3C10 6.2067x10-4 C11 - 2.6194X10-4 C13 5.5084x10-4C 15-1.7807x10-4 C 17-9.2688x10-5 C19 2.3851x10-4C 21-6.1960x10-5 C22 1.1482x10-7 C24-7.7827x10-6C26 4.1871x10-5 C28 8.9363x10-6 FFS**C4 -1.1936x10-2C6 1.5613x10-2 C8 9.8371x10-4C 10-3.2433x10-4 C 11-5.0154x10-4 C13 3.1318x10-3C15 - 6.5157X10-6 C17 -2.8893X10-4 C19 - 1.1561X10-3C21 3.2209X10-5 C22 3.9739X10-5 C24 7.0920X10-5C26 1.2812X10-4 C 28-3.3532X10-6 FFS**C4 2.1168x10-2 C6 3.1444x10-2 C8 -1.2773x10-2C 10-4.9250x10-3 C11 1.8772x10-4 C13-9.2233x10-4C 15-1.2437x10-3 C17 2.5286x10-2 C19 4.5186x10-3C 21-3.0342x10-4 C22 1.6796x10-2 C24 1.3450x10-2C26 1.6931x10-3 C 28-2.7316x10-5 FFS**C4 -7.6734x10-1 C6 -2.4281x10-1 C8 1.0370x10-2C 10-3.9036x10-2 C11 5.0781x10-1 C13 3.5355x10-1C15 5.0029x10-2 Eccentricity (1) X 0.00 Y -1.50 Z 0.00alpha 0.00 beta 0.00 gamma 0.00 Eccentricity (2) X 0.00 Y 1.00Z 5.00alpha -44.98 beta 0.00 gamma 0.00 Eccentricity (3) X 0.00 Y 2.76 Z 1.84alpha -75.17 beta 0.00 gamma 0.00 Eccentricity (4) X 0.00 Y -1.00 Z 4.95alpha -60.82 beta 0.00 gamma 0.00 Eccentricity X (5) 0.00 Y2.60 Z 1.61alpha -67.95 beta 0.00 gamma 0.00 Eccentricity (6) X 0.00Y -3.01 Z 0.75alpha -83.98 beta 0.00 gamma 0.00

eccentricity X (7) 0.00 Y-3.97 Z 0.94alpha -98.76 beta 0.00 gamma 0.00 .
[0171]
The 4th page number of an example Radius of curvature Spacing Eccentricity Refractive index Abbe number body side infinity 1000. 00 1 FFS** Eccentricity (1) 1.5254 56.3 2 FFS** (RS) Eccentricity (2) 1.5254 56.3 3 FFS** (RS) Eccentricity (3) 1.5254 56.3 4 FFS** Eccentricity (2) 5 infinity Eccentricity (4) 1.5254 56.36 infinity Eccentricity (5) 1001.00 - 3.45 7 FFS** (DOE) Eccentricity (6) 8 infinity (drawing side) Eccentricity (7) 9 FFS** (DOE) Eccentricity (6) 1001.00 - 3.4510 infinity Eccentricity (5) 1.5254 56.3 11 infinity Eccentricity (4) 12FFS** eccentricity (2) 1.525456.3 13 FFS** (RS) Eccentricity (8) 1.5254 56.3 14 FFS** eccentricity (9) Image Field infinity Eccentricity (10) FFS**C4 -5.1153x10-3C6 1.3925x10-2 C8 -7.3841x10-3C 10-1.1875x10-2 C 11-7.5853x10-5 C131.2571x10-3C15 1.6283x10-3 C17 5.6232x10-5 C19 2.0110x10-4C 21-4.8468x10-4 C22 9.0171x10-7 C24-1.1171x10-5C 26-2.0169x10-5 C28 6.5369x10-5 FFS**C4 1.4932x10-2 C6 -1.9540x10-3 C8 4.4504x10-3C 10-2.4909x10-3 C11 6.1319x10-5 C13 8.8673x10-4C 15-2.8323x10-4 C17 7.3968x10-6 C19 4.5864x10-5C 21-2.3171x10-6 C22 5.2961x10-8 C24-4.5057x10-7C 26-2.4771x10-6 C 281.8540x10-6 FFS**C4 -2.9939x10-3 C6 -1.1909x10-2 C8 1.2713x10-2C 10-9.0051x10-4 C 11-1.3110x10-4 C13-4.5404x10-3C15 5.2681x10-4 C17 4.0962x10-5 C19 1.1500x10-3C21 7.2718x10-5 C 22-1.2274x10-6 C24-7.7261x10-6C 26-1.0427x10-4 C 28-2.2896x10-5 FFS**C4 -6.1596x10-7 C6 3.4175x10-6 C8 -3.2523x10-6C10 - 9.3052X10-7 C11 - 4.0783X10-7 C13-5.9660X10-6C 15-2.3863X10-6 C 17-2.8541X10-7 C19-1.9365X10-6C 21-5.8348X10-7 FFS**C4 2.3949x10-2 C6 3.3604x10-2C8 -5.7943x10-4C10 9.6778x10-4 C 11-8.4834x10-4 C13-4.2016x10-3C15 2.3946x10-4 C 17-3.0987x10-3 C19 2.4318x10-3C 21-4.9242x10-4 C22 7.0481x10-4 C24-2.4279x10-3C 26-1.3842x10-3 C28 1.6279x10-4 FFS**C4 -1.0093 C6 -2.4736x10-1 C8 -1.4848C 10-1.3260x10-2 C11 2.9043x10-1 C13-8.9842x10-1C15 5.2718x10-2 Eccentricity (1) X 0.00 Y -1.50 Z 0.00alpha 0.00 beta 0.00 gamma 0.00 Eccentricity (2) X 0.00 Y 1.12 Z 5.50alpha -50.08 beta 0.00 gamma 0.00 Eccentricity (3) X 0.00 Y 3.00 Z 2.00alpha -87.13 beta 0.00 gamma 0.00 Eccentricity (4) X 0.00 Y 0.07 Z 5.03alpha -50.80 beta 0.00 gamma 0.00 Eccentricity (5) X 0.00 Y 0.11 Z 5.46alpha -50.799815 beta 0.00 gamma 0.00 Eccentricity (6) X 0.00 Y 0.57 Z 6.03alpha -50.799876 beta 0.00 gamma 0.00 Eccentricity (7) X 0.00 Y -0.88 Z 5.60alpha -59.62 beta 0.00 gamma 0.00 Eccentricity (8) X 0.00 Y 2.60 Z 1.00alpha -67.35 beta 0.00 gamma 0.00 Eccentricity (9) X 0.00 Y -3.00 Z 1.11alpha -107.34 beta 0.00 gamma 0.00 Eccentricity X (10) 0.00 Y-3.84 Z 0.84alpha -83.74 beta 0.00 gamma 0.00 .
[0172]
The 5th page number of an example Radius of curvature Spacing Eccentricity Refractive index Abbe number body side infinity 1000. 00 1 FFS** Eccentricity (1) 1.5254 56.3 2 FFS** (RS) Eccentricity (2) 1.5254 56.3 3 FFS** (RS) Eccentricity (3) 1.5254 56.3 4 FFS** Eccentricity (2) 5 infinity (drawing side) Eccentricity (4) 6FFS** Eccentricity (2) 1.5254 56.37 FFS** (RS) Eccentricity (5) 1.525456.3 8 FFS** eccentricity (6) 9 FFS** (DOE) eccentricity (7) 1001.00 - 3.45 10 Infinity Eccentricity (8) 1.5254 56.3 11 infinity Eccentricity (9) Image Field infinity eccentricity (10) FFS**C4 2.7110x10-3 C6 -4.1822x10-2 C8 -8.3156x10-3C 10-2.6287x10-2 C 11-8.1512x10-6 C13 4.1432x10-3C15 - 6.5747X10-4 C17 2.9008x10-6 C19 1.9125x10-4C21 2.6876x10-4 C22-8.9097x10-6C24-7.0018x10-5C 262.5234x10-6 C 28-3.2872x10-5 FFS**C 4-6.3232x10-3 C6 6.0261x10-3 C8 -3.2915x10-4C 10-4.4498x10-3 C 11-1.7090x10-5 C13 1.7254x10-3C15 7.9047x10-4 C 17-1.5791x10-4 C19 3.8668x10-4C21 6.0282x10-5 C 22-1.8162x10-5 C24-3.4431x10-5C26 5.1730x10-5 C28 9.2060x10-7 FFS**C4 -1.6315x10-2 C6 1.2307x10-2 C8 -1.8756x10-3C10 6.2970x10-4 C11 9.5379x10-5 C13 1.3103x10-3C 15-1.1967x10-4 C 17-2.8876x10-5 C19-8.6467x10-4C 21-5.1857x10-5 C 22-8.1252x10-5 C24 1.2131x10-4C26 1.3258x10-4 C 286.3820x10-6 FFS**C4 2.9891x10-2 C6 3.0951x10-2 C8 -9.3571x10-3C10 - 5.2875X10-3 C11 - 5.1673X10-3 C13 - 5.1317X10-4C 15-1.1087X10-3 C17 2.6635x10-3 C19 1.8630x10-3C 21-2.6829x10-4 C22 3.4886x10-3 C24 1.8096x10-3C26 8.2598x10-4 C 28-2.4770x10-5 FFS**C4 -6.8396x10-1C6 -2.0892x10-1 C8-1.7517x10-1C 10-1.2761x10-2 C11 4.5728x10-1 C13 5.5687x10-1C15 3.3352x10-2 FFS**C4 1.0559x10-4 C6 3.9513x10-5 C8 1.8847x10-4C10 1.6785x10-4 C11 - 2.8750X10-4 C13-4.6702X10-3C15 3.1902X10-5 C17 4.4625X10-3 C19 2.0071X10-2C 21-4.6995X10-5 Eccentricity (1) X 0.00 Y -

1.50 Z 0.00alpha 0.00 beta 0.00 gamma 0.00 Eccentricity (2) X 0.00 Y 0.34 Z 4.92alpha -50.44 beta 0.00 gamma 0.00 Eccentricity (3) X 0.00 Y 2.80 Z 1.89alpha -74.09 beta 0.00 gamma 0.00 Eccentricity (4) X 0.00 Y -0.82 Z 5.86alpha -46.70 beta 0.00 gamma 0.00 Eccentricity (5) X 0.00 Y 2.64 Z 1.68alpha -66 07 Beta 0.00 Gamma 0.00 Eccentricity (6) X 0.00 Y -3.05 Z 0.54alpha -81.32 beta 0.00 gamma 0.00 Eccentricity (7) X 0.00 Y -3.34 Z 0.76alpha -99.9998651 beta 0.00 gamma 0.00 Eccentricity (8) X 0.00 Y -3.36 Z 0.83alpha -100.00 beta 0.00 gamma 0.00 Eccentricity (9) X 0.00 Y -3.79 Z 0.66alpha -100.00 beta 0.00 gamma 0.00 eccentricity X (10) 0.00 Y -4.00 Z 0.71alpha -101.17 beta 0.00 gamma 0.00 .

[0173]

The 6th page number of an example Radius of curvature Spacing Eccentricity Refractive index Abbe number body side infinity 10.00 1 FFS** Eccentricity (1) 1.5254 56.3 2 FFS** (RS) Eccentricity (2) 1.5254 56.3 3 FFS** (RS) Eccentricity (3) 1.5254 56.3 4 FFS** Eccentricity (2) 5 infinity (drawing side) Eccentricity (4) 6FFS** Eccentricity (2) 1.5254 56.37 FFS** (RS) Eccentricity (5) 1.525456.3 8 FFS** eccentricity (6) Image Field infinity Eccentricity (7) FFS**C 4-1.4579x10-2 C6 -1.0257x10-1 C8 -9.2040x10-4C 10-1.0489x10-2 C 11-9.9035x10-5 C13 5.9168x10-3C15 4.8469x10-3 C 17-8.7514x10-6 C19 1.2191x10-3C 21-9.9794x10-4 FFS**C 41.3960x10-2 C6 1.2346x10-2C8 2.4723x10-3C10 1.0147x10-4 C 11-1.6176x10-4 C13 8.1886x10-4C15 2.0947x10-5 C 17-1.7977x10-4 C19 4.1117x10-5C 21-1.1700x10-4 FFS**C4 9.3942x10-3 C6 1.7229x10-2 C8 2.3970x10-3C10 3.5790x10-5 C11 2.9999x10-4 C13 3.8118x10-5C 15-1.6410x10-4 C 17-1.3152x10-4 C19-1.6937x10-5C 21-5.3560x10-6 FFS**C4 4.6653x10-2 C6 3.4104x10-2 C8 -1.6228x10-2C10 - 7.5431X10-3 C11 - 3.0449X10-3 C13-1.8865X10-3C15 7.5485X10-4 C17 1.5596X10-3 C19 1.3141X10-3C21 4.0652X10-4 FFS**C4 -3.3176x10-1 C6 -1.4184x10-1C8 2.4167x10-1C10 1.2728x10-1 C11 8.8749x10-2 C13-1.0491x10-1C 15-6.7796x10-2 Eccentricity (1) X 0.00 Y 0.58 Z 0.00alpha 0.00 beta 0.00 gamma 0.00 Eccentricity (2) X 0.00 Y 1.20 Z 4.13alpha -47.90 beta 0.00 gamma 0.00 Eccentricity (3) X 0.00 Y 1.40 Z 0.70alpha -68.85 beta 0.00 gamma 0.00 Eccentricity (4) X 0.00 Y -1.00 Z 4.40alpha -48.05 beta 0.00 gamma 0.00 Eccentricity (5) X 0.00 Y 1.78 Z 1.68alpha -65.43 beta 0.00 gamma 0.00 Eccentricity (6) X 0.00 Y -1.39 Z 1.33alpha -61.77 beta 0.00 gamma 0.00 eccentricity (7) X 0.00 Y -2.47 Z 1.04alpha -97.55 beta 0.00 gamma 0.00 .

[0174] The value the conditional expression (1) in each above-mentioned example and (2)-related is as follows. In addition, when the upside MAJINARU beam of light and bottom MAJINARU beam of light to a chief ray were unsymmetrical, NAy (NA2) was calculated with both average.

実施例	走査に必要なスキャナ振れ角（°）		瞳倍率		X瞳倍率／Y瞳倍率	光源側NA		
	φy	φx	X瞳倍率 2φx／θx	Y瞳倍率 2φy／θy		NAx (NA1)	NAy (NA2)	NAx／NAy (NA1/NA2)
1	±7.95	±3.20	0.59	0.30	0.52	0.16	0.19	1.20
2	±10.6	±4.42	0.79	0.42	0.54	0.15	0.19	1.28
3	±12.6	±4.87	0.93	0.46	0.50	0.25	0.26	1.02
4	±12.2	±6.10	1.04	0.68	0.65	0.13	0.18	1.41
5	±10.0	±2.45	0.74	0.23	0.32	0.14	0.26	1.91
6	±20.5					0.22	0.37	1.73

[0175] Although the free sculptured surface of said definition type (a) constituted optical system from the above example, it cannot be overemphasized that optical system can be constituted also from a curved surface of other definitions.
[0176] As mentioned above, although the scan optical system of this invention has been explained based on an example, this invention is not limited to these examples, but many deformation is possible for it.
[0177] The scan optical system of the above this invention can be constituted as follows, for example.
[0178] [1] In the scan optical system which consists of an optical deflection means to deflect the light from the light source and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed Said image formation optical system most in the field which has the optical power of said optical member including an optical member the field by the side of a scan layer-ed in the independent operating surface of a transparency operation Scan optical system characterized by including the page [2nd / or more] reflector containing the 1st [at least] page of the nonrotation plane of symmetry which said optical member has optical power and carried out eccentricity to the shaft top chief ray.
[0179] [2] Scan optical system of one above-mentioned publication characterized by constituting said optical member as a prism member.
[0180] [3] Scan optical system of one above-mentioned publication characterized by including the 1st [at least] page of the combination side of transparency and an echo of said optical member.
[0181] [4] Scan optical system of two above-mentioned publication characterized by being a 3rd page configuration including the 1st page of the combination side of transparency and an echo of said prism member.
[0182] [5] The light source and the condensing optical system which makes light from said light

source abbreviation parallel light, In the scan optical system which consists of an optical deflection means to deflect the injection light from said condensing optical system, and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed Scan optical system characterized by the field of the last of said condensing optical system which injects from said condensing optical system and carries out incidence to said optical deflection means, and the field of the beginning of said image formation optical system which carries out incidence to said image formation optical system from said optical deflection means being the same sides.
[0183] [6] Scan optical system of five above-mentioned publication characterized by the optical operating surface before and behind said optical deflection means being a transparency side.
[0184] [7] Scan optical system of five above-mentioned publication characterized by said image formation optical system including the 1st [at least] page of the combination side of transparency and an echo.
[0185] [8] The light source and the condensing optical system which makes light from said light source abbreviation parallel light, In the scan optical system which consists of an optical deflection means to deflect the injection light from said condensing optical system, and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed For said prism member, said scan optical system is [said a part of condensing optical system and] the scan optical system to which it is characterized by including said a part of image formation optical system at least at least including a prism member.
[0186] [9] Scan optical system of eight above-mentioned publication characterized by said condensing optical system and said image formation optical system consisting of one prism member.
[0187] [10] The light source and the condensing optical system which makes light from said light source abbreviation parallel light, In the scan optical system which consists of an optical deflection means to deflect the injection light from said condensing optical system, and to scan on a scan layer-ed, and image formation optical system which carries out image formation of the light deflected by said optical deflection means to a scan layer-ed Scan optical system the above 1 and 5 characterized by reflecting 3 times or more in the sum total of said condensing optical system and said image formation optical system, or given in eight.
[0188] [11] Scan optical system of eight above-mentioned publication characterized by the part and said prism member which includes said a part of image formation optical system at least of said condensing optical system having the combination side of transparency and an echo at least.
[0189] [12] Scan optical system of 11 above-mentioned publication to which the part and said prism member which includes said a part of image formation optical system at least of said condensing optical system are characterized by having the combination side which performs three optical operations of two transparency operations and one reflex action at least.
[0190] [13] Set at least to the part and said prism member which includes said a part of image formation optical system at least of said condensing optical system. The portion of said condensing optical system included in said prism member at least the nonrotation which has the plane of incidence to said prism member, and optical power, and carried out eccentricity to the shaft top chief ray -- a plane of symmetry reflector -- The portion of said image formation optical system included in said prism member including the 3rd page of the injection sides from a prism member the nonrotation which has the re-plane of incidence to said prism member, and optical power, and carried out eccentricity to the shaft top chief ray at least -- the scan optical system of eight above-mentioned publication characterized by including the 3rd page of a plane of symmetry reflector and the re-injection sides from a prism member.
[0191] [14] Scan optical system the above 1 and 5 characterized by the nonrotation plane of symmetry of said image formation optical system having only one plane of symmetry about a configuration, or given in eight.
[0192] [15] Scan optical system the above 1 and 5 characterized by including the nonrotation plane of symmetry in which said condensing optical system has only one plane of symmetry

about a configuration, or given in eight.
[0193] [16] Scan optical system the above 1 and 5 characterized by being the free sculptured surface in which the nonrotation plane of symmetry of said image formation optical system has only one plane of symmetry about a configuration, or given in eight.
[0194] [17] Scan optical system the above 1 and 5 characterized by said optical deflection means being a two-dimensional optical deflection means which carries out a two-dimensional deflection with one optical deflection means, or given in eight.
[0195] [18] Scan optical system the above 1 and 5 characterized by the deflection angle by said optical deflection means changing in the shape of a sine wave, or given in eight.
[0196] [19] Scan optical system of 18 above-mentioned publication to which the aforementioned deflection angle is characterized by using 95% or less of the amplitude of an optical deflection angle for a scan in an optical deflection means to change in the shape of a sine wave.
[0197] [20] Scan optical system the above 1 and 5 characterized by amending electric uniform scan nature, or given in eight.
[0198] [21] Scan optical system the above 1 and 5 characterized by the deflection angle by said optical deflection means changing to a linear, or given in eight.
[0199] [22] Scan optical system the above 1 and 5 to which said image formation optical system has only one plane of symmetry about a configuration, eccentricity is carried out only by the plane-of-symmetry inboard about the configuration, and said scan optical system is characterized by satisfying a degree type, or given in eight.
[0200]
phi 2 theta 1 / phi 1 theta2 <1 ... (1)
Here, it is the single-sided deflection angle of an optical deflection means required for the scan of 2phi2, plane of symmetry, and the scan layer-ed of the direction of the orthotomic surface about the single-sided deflection angle of an optical deflection means required for the scan of the scan layer-ed of theta 1 and the direction of plane of symmetry in the half-field angle of image formation optical system [in / for the half-field angle of the image formation optical system in the plane-of-symmetry inboard by the side of a scan layer-ed / theta 2 plane of symmetry, and the direction of the orthotomic surface] 2phi1 It carries out
[0201] [23] Scan optical system of 22 above-mentioned publication characterized by satisfying the following conditional expression.
[0202]
NA2/NA 1> 1 ... (2)
Here, numerical aperture of the flux of light from the light source in the plane of symmetry and the perpendicular direction of the flux of light which carries out incidence from the light source in the plane-of-symmetry inboard about a configuration to condensing optical system concerning NA2 and a configuration in numerical aperture to condensing optical system which carries out incidence is set to NA1.
[0203]
[Effect of the Invention] By constituting scan optical system focusing on a prism member including reflex action, this invention can reduce the components mark of scan optical system, and can make optical system small.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is optical-path drawing of the scan optical system of the example 1 of this invention.
[Drawing 2] It is drawing showing the example of a configuration of the light source in the case of carrying out color display using two or more sources of the homogeneous light.
[Drawing 3] It is the plan of one example of a two-dimensional micro machine scanner.
[Drawing 4] It is optical-path drawing of the scan optical system of the example 2 of this invention.
[Drawing 5] It is optical-path drawing of the scan optical system of the example 3 of this invention.
[Drawing 6] It is optical-path drawing of the scan optical system of the example 4 of this invention.
[Drawing 7] It is optical-path drawing of the scan optical system of the example 5 of this invention.
[Drawing 8] It is optical-path drawing of the scan optical system of the example 6 of this invention.
[Drawing 9] It is drawing showing the basic form configuration of a reflective mold optical deflection means and a transparency mold optical deflection means.
[Drawing 10] It is drawing showing the configuration of one conventional scan optical system.
[Drawing 11] It is drawing showing the configuration of another another conventional scan optical system.
[Description of Notations]
1 -- Shaft top chief ray
1T -- The 1st transparency side
1R -- The 1st reflector
2T -- The 2nd transparency side
2R -- The 2nd reflector
3T -- The 3rd transparency side
3R -- The 3rd reflector (total reflection)
4T -- The 4th transparency side
10 -- Scan optical system (prism)
11 -- Light source
11B -- Illuminant B
11R -- R light source
11G -- G light source
12 -- Optical deflection means (scanner)
13 -- DOE (diffracted-light study element)
14 -- Diffraction side
21, 22, 23 -- Light source prism
24 25 -- Dichroic mirror
30 -- Outer frame

31 -- Torsion bar spring
32 -- Medium frame
33 -- Torsion bar spring
34 -- Mirror section

[Translation done.]

(d)

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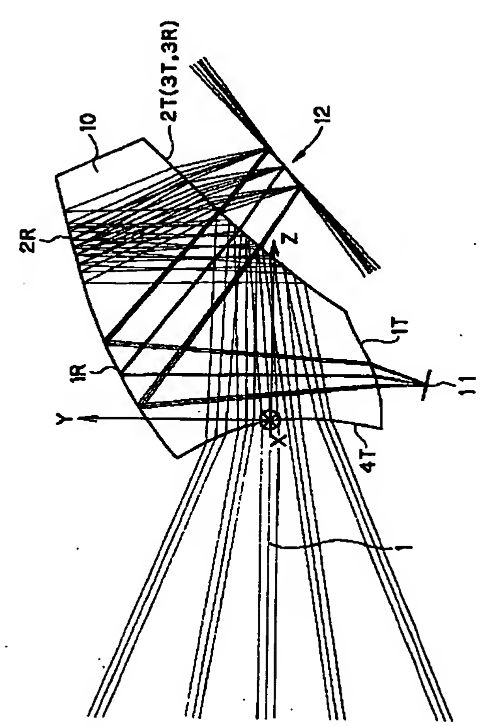
(54)【発明の名称】　走査光学系

(57)【要約】
【課題】　少ない光学素子によって構成された小型な走査光学系。
【解決手段】　プリズムからなる走査光学系１０は、光源１１から像面（被走査面）に到る順光線追跡で、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔで構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、２次元スキャナ１２で反射偏向される。反射偏向された光は、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を２次元走査する。



【特許請求の範囲】

【請求項１】　光源からの光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、

前記結像光学系が光学部材を含み、前記光学部材の光学パワーを有する面の中最も被走査面側の面が透過作用の単独作用面で、

前記光学部材が光学パワーを有し軸上主光線に対して偏心した非回転対称面を少なくとも１面含む２面以上の反射面を含むことを特徴とする走査光学系。

【請求項２】　光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、

前記集光光学系から射出して前記光偏向手段に入射する前記集光光学系の最後の面と、前記光偏向手段から前記結像光学系に入射する前記結像光学系の最初の面が同一面であることを特徴とする走査光学系。

【請求項３】　光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、

前記走査光学系がプリズム部材を含み、前記プリズム部材は、少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含むことを特徴とする走査光学系。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、走査光学系に関し、特に、光源から発せられた光を光偏向手段によって偏向して被照射面を２次元走査する走査光学系に関するものである。

【０００２】

【従来の技術】従来の走査光学系の例として図１０、図１１に示したようなものがある。図１０の場合（特開平８－３２７９２６号）、この走査光学系は、まず、コリメータレンズ５２、スリット５３、シリンドリカルレンズ５４で構成される集光光学系により、光源５１の光をコリメートし、回転多面鏡５５に導く。回転多面鏡５５で反射偏向された光を、レンズ２枚で構成される結像レンズ５６により結像面５７を１次元走査する。

【０００３】図１１の場合（特開平８－１４６３２０号）は、光源６１の光をコリメータレンズ６２で平行にし、偏向手段６３で反射偏向した後、結像手段６４で被照射面６５を２次元走査している。

【０００４】

【発明が解決しようとする課題】しかしながら、図１０の場合は、光学系を構成する光学素子の数が多いので、必要な光学性能を得るための組み立て調整の精度が厳しくなり、コストも増加する。また、図１１の場合は、光学系の具体的な構成が開示されていない。

【０００５】本発明はこのような従来技術の問題点を解決するためになされたものであり、その目的は、少ない光学素子によって構成された小型な走査光学系を提供することである。

【０００６】

【課題を解決するための手段】上記目的を達成する本発明の第１の走査光学系は、光源からの光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記結像光学系が光学部材を含み、前記光学部材の光学パワーを有する面の中最も被走査面側の面が透過作用の単独作用面で、前記光学部材が光学パワーを有し軸上主光線に対して偏心した非回転対称面を少なくとも１面含む２面以上の反射面を含むことを特徴とするものである。

【０００７】この走査光学系は、後記の実施例１～６が対応する。

【０００８】この走査光学系の作用効果を説明する。光学パワーを有し軸上主光線に対して偏心した非回転対称面を少なくとも１面含む２面以上の反射面で反射することで、折り畳みの効果により光学系を小型化することができる。光学パワーを有する反射面は、レンズ作用と偏向作用を持つので、小型化の効果が大きい。

【０００９】光学パワーを有し軸上主光線に対して偏心した反射面を使用した光学系では、光学パワーを有し偏心した反射面に対して光線が斜めに入射するために、軸上光線でも偏心によるコマ収差、非点収差等が発生する。この反射面を回転非対称面とすることで、この偏心収差を補正することができる。

【００１０】また、一般に、走査光学系において光偏向手段によって偏向された光を偏心した反射面に入射させる場合、直線走査性が確保できないという問題が生ずるが、結像光学系の反射面を回転非対称な反射面とすることで直線走査性を確保することができる。

【００１１】また、回転非対称面を使うことで、結像光学系を２次元ｆアークサインθレンズや２次元ｆθレンズにし、被走査面を等速走査するのが容易になる。

【００１２】回転多面鏡（ポリゴンミラー）等のように偏向角がリニアに変化する光偏向手段を使う場合は、結像光学系でマイナスのディストーションを発生させ結像光学系をｆθレンズとすることで、被走査面を等速走査することができる。また、ガルバノミラーのように偏向角が正弦波状に変化する偏向手段を使う場合は、偏向角の大きさに応じたディストーション（偏向角が小さい場合はプラスのディストーション、偏向角が大きい場合はマイナスのディストーション）を結像光学系で発生させ

結像光学系をｆアークサインθレンズとすることで、被走査面を等速走査することができる。

【００１３】この場合、結像光学系の光学パワーを有する面の中最も被走査面側の面は、各画角の光線位置が大きく異なり光束径も小さいので、ディストーションの補正に有効である。この面を透過作用と反射作用、透過作用と透過作用のように複数の光学作用の兼用面にしようとすると、兼用面にするための制約条件によりディストーションの補正作用が劣化するので、透過作用のみの単独作用面とすることでディストーションの補正を有効に行うことができる。また、画角の確保も容易になる。

【００１４】本発明の第２の走査光学系は、第１の走査光学系において、前記光学部材がプリズム部材として構成されていることを特徴とするものである。

【００１５】この走査光学系は、後記の実施例１～６が対応する。

【００１６】この走査光学系の作用効果を説明する。一般に、反射面は屈折面より偏心誤差を厳しく制御しなければならないので、組み立て調整作業が大変になる。しかし、光学部材の反射面をプリズム部材の１面として構成すれば、この問題が解決できる。

【００１７】また、偏向手段からプリズム部材に入射する光線が、プリズム部材の入射面で屈折されるので、以降の面への軸外光線の入射光線高を低く設定することができる。そのため、光学系を小型にできると共に、より大きな画角を実現することができる。また、軸外光線の従属光線高も低くなるので、コマ収差等の発生を抑制することもできる。

【００１８】本発明の第３の走査光学系は、第１の走査光学系において、前記光学部材が透過と反射の兼用面を少なくとも１面含むことを特徴とするものである。

【００１９】この走査光学系は、後記の実施例１～６が対応する。

【００２０】この走査光学系の作用効果を説明する。透過と反射という２つの作用を同一面で行うので、結像光学系を構成する面数を削減し、結像光学系を単純で小型なものにすることができる。この場合、反射作用を全反射作用とすれば、なお好ましい。兼用面における反射を全反射ではなく反射膜での反射により行おうとすると、反射面用の反射膜を透過面用の透過領域と離れた別の位置に形成する必要がある。このため、光学系が大型化する、発生収差が増える等の問題が生ずる。また、反射膜を作製する必要があるので、コストがアップする。

【００２１】本発明の第４の走査光学系は、第２の走査光学系において、前記プリズム部材が透過と反射の兼用面を１面含む３面構成であることを特徴とするものである。

【００２２】この走査光学系は、後記の実施例１～６が対応する。

【００２３】この走査光学系の作用効果を説明する。第２の走査光学系のプリズム部材を使用する場合、少なくとも、プリズム部材への入射面、２面の反射面、プリズム部材からの射出面が必要となる。兼用面、透過面、反射面からなる３面という最小の面数でプリズム部材を構成できるので、プリズム部材を単純で小型なものにすることができる。

【００２４】本発明の第５の走査光学系は、光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記集光光学系から射出して前記光偏向手段に入射する前記集光光学系の最後の面と、前記光偏向手段から前記結像光学系に入射する前記結像光学系の最初の面が同一面であることを特徴とするものである。

【００２５】この走査光学系は、後記の実施例１～６が対応する。

【００２６】この走査光学系の作用効果を説明する。光源から被走査面に向かう順光線追跡において、光偏向手段の前後の面である「集光光学系を構成する最後の面」と「結像光学系の最初の面」を別々の面とする場合、この２面の位置を離す必要があるので、光偏向手段と光偏向手段の前後の面を離すか、光偏向手段に対する光線入射角を大きくする必要がある。

【００２７】しかし、光偏向手段と光偏向手段の前後の面を離すと光学系が大型化する。また、光偏向手段に対する光線入射角を大きくすると光偏向手段の面積が大きくなるので、大きな偏向角や高い偏向周波数（走査周波数）を確保するのが難しくなる。これは、特に、特開平１０－２０２２６号で開示されているようなマイクロマシン技術を利用して製作したマイクロマシンスキャナのように単一の反射面で構成される光偏向手段の場合に大きな問題点となる。

【００２８】光偏向手段の前後の面を同一面とすれば、光偏向手段に対する光線入射角を小さくすることができる。その結果、光偏向手段の面積を小さくすることができるので、光偏向手段の偏向角を大きくしたり偏向周波数（走査周波数）を高周波にすることができる。

【００２９】本発明の第６の走査光学系は、第５の走査光学系において、前記光偏向手段の前後の光学作用面が透過面であることを特徴とするものである。

【００３０】この走査光学系は、後記の実施例１～６が対応する。

【００３１】この走査光学系の作用効果を説明する。光源から被走査面に向かう順光線追跡において、光偏向手段の前後の光学作用面を反射面とすると、集光光学系を構成する最後の面（反射面１）と結像光学系を構成する最初の面（反射面２）の両方が反射面になるので、反射面１への入射光と反射型光偏向手段の干渉、反射面２での反射光と反射型光偏向手段の干渉を防ぐために、反射

型光偏向手段への光線入射角を大きくするか、反射型光偏向手段の前後の面（反射面１＝反射面２）と光偏向手段の距離を大きくするか、光偏向手段に対する入射面と主走査面が角度をなす（平行でない）ようにする必要が生ずる。しかし、それぞれの方法では、光偏向手段の面積が大きくなる、光学系の大きさが大きくなる、偏心収差の補正が困難になる等の問題が生ずる。

【００３２】光偏向手段の前後の光学作用面を透過面とすれば、このような問題点を解消することができる。

【００３３】本発明の第７の走査光学系は、第５の走査光学系において、前記結像光学系が透過と反射の兼用面を少なくとも１面含むことを特徴とするものである。

【００３４】この走査光学系は、後記の実施例１～６が対応する。

【００３５】この走査光学系の作用効果を説明する。透過と反射という２つの作用を同一面で行うので、結像光学系を構成する面数を削減し、結像光学系を単純で小型なものにすることができる。この場合、反射作用を全反射作用とすれば、なお好ましい。兼用面における反射を全反射ではなく反射膜での反射により行おうとすると、反射面用の反射膜を透過面用の透過領域と離れた別の位置に形成する必要がある。このため、光学系が大型化する、発生収差が増える等の問題が生ずる。また、反射膜を作製する必要があるので、コストがアップする。

【００３６】本発明の第８の走査光学系は、光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記走査光学系がプリズム部材を含み、前記プリズム部材は、少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含むことを特徴とするものである。

【００３７】この走査光学系は、後記の実施例１～６が対応する。

【００３８】この走査光学系の作用効果を説明する。集光光学系の一部と結像光学系の一部を一つの光学素子で構成できるので、走査光学系を構成する部品点数を削減することができる。その結果、所望の性能を得るための組み立て時の位置調整作業が楽になるし、低コスト化することができる。

【００３９】本発明の第９の走査光学系は、第８の走査光学系において、前記集光光学系と前記結像光学系が一つのプリズム部材で構成されていることを特徴とするものである。

【００４０】この走査光学系は、後記の実施例１～３、６が対応する。

【００４１】この走査光学系の作用効果を説明すると、第８の走査光学系の効果がより大きくなる。

【００４２】本発明の第１０の走査光学系は、光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる第１、５又は８の走査光学系において、前記集光光学系と前記結像光学系との合計で３回以上反射することを特徴とするものである。

【００４３】この走査光学系は、後記の実施例１～６が対応する。

【００４４】この走査光学系の作用効果を説明する。合計３回以上反射させることで折りたたみの効果が大きくなり、走査光学系全体の小型化の効果をより大きくすることができる。

【００４５】本発明の第１１の走査光学系は、第８の走査光学系において、少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含む前記プリズム部材が透過と反射の兼用面を持つことを特徴とするものである。

【００４６】この走査光学系は、後記の実施例１～６が対応する。

【００４７】この走査光学系の作用効果を説明する。透過と反射という２つの作用を同一面で行うので、走査光学系を構成する面数を削減し、光学系を単純で小型なものにすることができる。この場合、反射作用を全反射作用とすれば、なお好ましい。兼用面における反射を全反射ではなく反射膜での反射により行おうとすると、反射面用の反射膜を透過面用の透過領域と離れた別の位置に形成する必要がある。このため、光学系が大型化する、発生収差が増える等の問題が生ずる。また、反射膜を作製する必要があるので、コストがアップする。

【００４８】本発明の第１２の走査光学系は、第１１の走査光学系において、少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含む前記プリズム部材が２回の透過作用と１回の反射作用の３つの光学作用を行う兼用面を持つことを特徴とするものである。

【００４９】この走査光学系は、後記の実施例１～６が対応する。

【００５０】この走査光学系の作用効果を説明すると、第１１の走査光学系の効果が更に大きくなる。また、プリズム部材の光偏向手段に面した面をこの兼用面とすると、第５の走査光学系の作用効果を得ることができる。

【００５１】本発明の第１３の走査光学系は、第８の走査光学系において、少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含む前記プリズム部材において、前記プリズム部材に含まれる前記集光光学系の部分が、少なくとも、前記プリズム部材への入射面、光学パワーを有し軸上主光線に対して偏心した非回転対称面な反射面、プリズム部材からの射出面の３面を含み、前記プリズム部材に含まれる前記結像光学系

の部分が、少なくとも、前記プリズム部材への再入射面、光学パワーを有し軸上主光線に対して偏心した非回転対称面な反射面、プリズム部材からの再射出面の３面を含むことを特徴とするものである。

【００５２】この走査光学系は、後記の実施例１～６が対応する。

【００５３】この走査光学系の作用効果を説明する。光学パワーを有する反射面は、レンズ作用と偏向作用を持つので、光学系を小型化する効果が大きい。本走査光学系の場合、集光光学系、結像光学系の両方を小型化できるので、走査光学系全体を小型化できる。

【００５４】しかし、光学パワーを有し軸上主光線に対して偏心した反射面を使用した光学系では、偏心した反射面に対して光線が斜めに入射するために、軸上光線でも偏心によるコマ収差、非点収差等が発生する。この反射面を回転非対称面とすることで、この偏心収差を補正することができる。

【００５５】また、一般に、走査光学系において光偏向手段によって偏向された光を偏心した反射面に入射させる場合、直線走査性が確保できないという問題が生ずるが、結像光学系の反射面を非回転対称な反射面とすることで直線走査性を確保することができる。また、回転非対称面を使うことで、結像光学系を２次元ｆアークサインθレンズや２次元ｆθレンズにし、走査光学系で被走査面を等速走査をすることができる。

【００５６】また、プリズム部材に含まれる集光光学系の部分に非回転対称な反射面を使用することで、ＬＤのように楕円状の断面形状を持つ光源に対するビーム整形作用を持たせたり、面倒れ補正機能を持たせることができる。

【００５７】一般に、反射面は屈折面より偏心誤差を厳しく制御しなければならないので、組み立て調整作業が大変になる。しかし、反射面をプリズム部材の１面として構成すれば、この反射面の調整作業が削減できる。

【００５８】また、偏向手段からプリズム部材の結像光学系の部分に入射する光線がプリズム部材の入射面で屈折されるので、以降の面への軸外光線の入射光線高を低く設定することができる。そのため、光学系を小型にできると共に、より大きな画角を実現することができる。また、軸外光線の従属光線高も低くなるので、コマ収差等の発生を抑制することもできる。

【００５９】本発明の第１４の走査光学系は、第１、５又は８の走査光学系において、前記結像光学系の非回転対称面が形状に関する対称面を１つだけ持つことを特徴とするものである。

【００６０】この走査光学系は、後記の実施例１～６が対応する。

【００６１】この走査光学系の作用効果を説明すると、形状に関する対称面を持つことにより製作性を向上させることができる。

【００６２】本発明の第１５の走査光学系は、第１、５又は８の走査光学系において、前記集光光学系が形状に関する対称面を１つだけ持つ非回転対称面を含むことを特徴とするものである。

【００６３】この走査光学系は、後記の実施例１～６が対応する。

【００６４】この走査光学系の作用効果を説明すると、回転非対称な面の作用効果は第１３の走査光学系と同じである。形状に関する対称面を１つ持つことによる作用効果は、第１４の走査光学系と同じである。以上の作用効果を集光光学系が持つ。

【００６５】本発明の第１６の走査光学系は、第１、５又は８の走査光学系において、前記結像光学系の非回転対称面が形状に関する対称面を１つだけ持つ自由曲面であることを特徴とするものである。

【００６６】この走査光学系は、後記の実施例１～６が対応する。

【００６７】この走査光学系の作用効果を説明する。本発明で使用する自由曲面とは、例えば以下の式（ａ）で定義されるものである。なお、その定義式のＺ軸が自由曲面の軸となる。

【００６８】

$$Z=cr^2/[1+\sqrt{\{1-(1+k)c^2r^2\}}]+\sum_{j=2}^{66}C_jX^mY^n \quad \cdots(a)$$

ここで、（ａ）式の第１項は球面項、第２項は自由曲面項である。

【００６９】球面項中、

ｃ：頂点の曲率

ｋ：コーニック定数（円錐定数）

$r=\sqrt{(X^2+Y^2)}$

である。

【００７０】自由曲面項は、

$$
\begin{aligned}
\sum_{j=2}^{66} C_j X^m Y^n
&= C_2 X + C_3 Y \\
&+ C_4 X^2 + C_5 XY + C_6 Y^2 \\
&+ C_7 X^3 + C_8 X^2 Y + C_9 XY^2 + C_{10} Y^3 \\
&+ C_{11} X^4 + C_{12} X^3 Y + C_{13} X^2 Y^2 + C_{14} XY^3 + C_{15} Y^4 \\
&+ C_{16} X^5 + C_{17} X^4 Y + C_{18} X^3 Y^2 + C_{19} X^2 Y^3 + C_{20} XY^4 \\
&\qquad + C_{21} Y^5 \\
&+ C_{22} X^6 + C_{23} X^5 Y + C_{24} X^4 Y^2 + C_{25} X^3 Y^3 + C_{26} X^2 Y^4 \\
&\qquad + C_{27} XY^5 + C_{28} Y^6 \\
&+ C_{29} X^7 + C_{30} X^6 Y + C_{31} X^5 Y^2 + C_{32} X^4 Y^3 + C_{33} X^3 Y^4 \\
&\qquad + C_{34} X^2 Y^5 + C_{35} XY^6 + C_{36} Y^7 \\
&\qquad \cdots\cdots
\end{aligned}
$$

ただし、C_j（ｊは２以上の整数）は係数である。

【００７１】上記自由曲面は、一般的には、Ｘ－Ｚ面、Ｙ－Ｚ面共に対称面を持つことはないが、本発明ではＸの奇数次項を全て０にすることによって、Ｙ－Ｚ面と平行な対称面が１つだけ存在する自由曲面となる。例えば、上記定義式（ａ）においては、C_2、C_5、C_7、C_9、C_{12}、C_{14}、C_{16}、C_{18}、C_{20}、C_{23}、C_{25}、C_{27}、C_{29}、C_{31}、C_{33}、C_{35}・・・の各項の係数を０にすることによって可能である。

【００７２】また、Ｙの奇数項を全て０にすることによって、Ｘ－Ｚ面と平行な対称面が１つだけ存在する自由曲面となる。例えば、上記定義式においては、C_3、C_5、C_8、C_{10}、C_{12}、C_{14}、C_{17}、C_{19}、C_{21}、C_{23}、C_{25}、C_{27}、C_{30}、C_{32}、C_{34}、C_{36}・・・の各項の係数を０にすることによって可能である。

【００７３】上記対称面の何れか一方を対称面としその対称面方向に偏心させることで、偏心により発生する非回転対称な収差を効果的に補正しながら同時に製作性も向上させることができる。

【００７４】なお、自由曲面の定義式は、Ｚｅｒｎｉｋｅ多項式等他の定義式としてもよい。

【００７５】本発明の第１７の走査光学系は、第１、５又は８の走査光学系において、前記光偏向手段が、１個の光偏向手段で２次元偏向する２次元光偏向手段であることを特徴とするものである。

【００７６】この走査光学系は、後記の実施例１～５が対応する。

【００７７】この走査光学系の作用効果を説明する。光偏向手段の面積を小さくするには、結像光学系の入射瞳付近に偏向手段を配置する必要がある。２つの１次元光偏向手段を使って２次元走査を行う場合、光偏向手段の大きさを小さくするには、２つの１次元光偏向手段を共役にするか２つの１次元光偏向手段の間隔を小さくする必要があり、光学系が複雑・大型化する、光学系のレイアウトに関する制約条件が増える等の問題点が生ずる。１つの光偏向手段で２次元偏向すれば、光学系のレイアウトがしやすく、光学系を小型で単純なものにすることができる。

【００７８】本発明の第１８の走査光学系は、第１、５又は８の走査光学系において、前記光偏向手段による偏向角が正弦波状に変化することを特徴とするものである。

【００７９】この走査光学系は、後記の実施例１、２、４～６が対応する（電気的像歪み補正を行えば実施例３も対応する。）。

【００８０】この走査光学系の作用効果を説明する。例えば、特開平１０－２０２２６号で開示されているようなマイクロマシン技術を利用して製作したマイクロマシンスキャナは反射ミラーを１面だけ持ち、高速走査をする場合、この反射ミラーは正弦波状に振動し光を反射偏向する。このような光偏向手段を使えば、光偏向手段を小型、低コスト、低消費電力にし、高速走査をすることができる。このとき、走査光学系の結像光学系をｆアークサインθレンズにしてやれば、被走査面を等速走査することができる。

【００８１】本発明の第１９の走査光学系は、第１８の走査光学系において、前記の偏向角が正弦波状に変化する光偏向手段において、光偏向角の振幅の９５％以下を走査に利用することを特徴とするものである。

【００８２】この走査光学系は、後記の実施例１、２、４～６が対応する（電気的像歪み補正を行えば実施例３も対応する。）。

【００８３】この走査光学系の作用効果を説明する。以下、ポリゴンミラー、ガルバノミラー等の反射型偏向器の場合で説明する。図９（ａ）に示すように、反射型偏向器（反射型偏向手段）の反射面の基準反射面からの振れ角ϕが、正弦波状に変化する偏向手段を使う場合、電気的な像歪み補正なしに等速走査するには、結像光学系をｆアークサインθレンズにする必要がある。

【００８４】反射面の振れ角が振幅ϕ_0 / kで正弦波状に変化する偏向手段において、振れ角の振幅のｋ倍の振れ角（$\pm\phi_0$）を利用して被走査面を走査するとする。

このとき、結像光学系をｆアークサインθレンズにするためには、次式を満たす必要がある（０＜ｋ≦１）。

【００８５】像高ｙ＝ｆ・２（ϕ_0／ｋ）arcsin｛φ／（ϕ_0／ｋ）｝

偏向が±２０°程度の場合、偏向角の全部に対して結像光学系をｆアークサインθレンズにするためには、非常に大きなプラスのディストーションを発生させる必要があり結像光学系の設計が困難である。そこで、φ／（ϕ_0／ｋ）の線形性が良い領域のみを利用すると、結像光学系をｆアークサインθレンズにするのが容易になる。

【００８６】ｋを０．９５以下にすると、φ／（ϕ_0／ｋ）の線形性がｋ＝１の場合と直線の中間程度以下となり、結像光学系をｆアークサインθレンズにするのが容易になる。その結果、光学系を単純で小型なものにすることができる。

【００８７】また、通常のディスプレイでも１７％程度のブランキング期間があるように、走査光学系においても電気的な処理の関係から偏向角の全部は使用できない。この場合、偏向手段の偏向角の振幅の９５％程度が上限となる。

【００８８】図９（ｂ）に示すように、音響光学偏向器ＡＯＤのような透過型の光偏向手段の場合は、以上の説明において２φを偏向角とみなしてやればよい。

【００８９】本発明の第２０の走査光学系は、第１、５又は８の走査光学系において、電気的な等速走査性の補正を行うことを特徴とするものである。

【００９０】この走査光学系は、何れの実施例実施例に適用してもよい。

【００９１】この走査光学系の作用効果を説明する。特に、２次元走査を行う場合、光偏向手段の偏向特性に合わせて結像光学系のディストーションを制御することで、２次元的な直線走査性・等速走査性を確保しようとすると光学系が複雑・大型化する。一方、高速な２次元走査をする場合、直線走査性の電気的な像歪み補正は２次元的な補正になるので、補正をリアルタイムに行うことは困難になる。

【００９２】そこで、直線走査性は結像光学系で確保し等速走査性は電気的な補正を行うことで確保するようにすると、光学系を単純で小型なものにすることができるし、電気的な像歪み補正は主走査方向の１本の走査線に対する補正になるので高速走査にも対応できる。

【００９３】この場合、正弦波状に変化する偏向角の振幅の全てを利用しようとすると、走査速度の速い像の中心付近と走査速度の遅い像の周辺付近の走査速度の差が大きくなりすぎる。その結果、電気的像歪み補正を行う場合でも、精度良く補正を行うことができなくなる。偏向角振幅の８５％程度を使用すると、等速走査性の補正が２段階程度でよくなるので好ましい。

【００９４】本発明の第２１の走査光学系は、第１、５又は８の走査光学系において、前記光偏向手段による偏向角がリニアに変化することを特徴とするものである。

【００９５】この走査光学系は、後記の実施例３が対応する（電気的像歪み補正を行えば実施例１、２、４～６も対応する。）。

【００９６】この走査光学系の作用効果を説明する。回転多面鏡（ポリゴンミラー）は等速回転しているので、光偏向角はリニアに変化する。光偏向手段として回転多面鏡（ポリゴンミラー）を使えば、光偏向手段で大きな偏向角を確保でき、走査光学系の画角を大きくすることができる。このとき、走査光学系の結像光学系をｆθレンズにすれば、被走査面を等速走査することができる。

【００９７】本発明の第２２の走査光学系は、第１、５又は８の走査光学系において、前記結像光学系が、形状に関する対称面を１つだけ持ち、その形状に関する対称面内方向のみで偏心しており、前記走査光学系が、次式を満足することを特徴とするものである。

【００９８】

$$\phi_2\,\theta_1/\phi_1\,\theta_2<1 \quad \cdots(1)$$

ここで、被走査面側の対称面内方向における結像光学系の半画角をθ_2、対称面と直交面方向における結像光学系の半画角をθ_1、対称面方向の被走査面の走査に必要な光偏向手段の片側偏向角を２ϕ_2、対称面と直交面方向の被走査面の走査に必要な光偏向手段の片側偏向角を２ϕ_1とする。

【００９９】ポリゴンミラー、ガルバノミラーのような反射型偏向手段の場合、走査に必要な反射ミラーの片側振れ角がϕ_1、ϕ_2であることに相当する。ここで言う反射ミラー面の片側振れ角は、被走査面の中心に対応する反射ミラー面からの最大ずれ角である。この場合、必ずしも光偏向手段の反射ミラーが±φ振れるというわけではない。反射ミラーの振幅の一部を利用して被走査面の走査を行う場合は、走査に利用するのが±φということである。また、音響光学偏向器ＡＯＤのような透過型の光偏向手段の場合は、片側偏向角が２ϕ_1、２ϕ_2に相当する（図９）。　この走査光学系は、後記の実施例１～６が対応する。

【０１００】この走査光学系の作用効果を説明する。ポリゴンミラー、ガルバノミラーのような反射型の光偏向手段を使用した場合で説明する（図９（ａ））。反射型光偏向手段の片側振れ角がφ（偏向角が２φ）のとき、結像光学系の走査半画角がθとする。このとき、順追跡における、結像光学系の瞳倍率＝２φ／θである。

【０１０１】結像光学系が形状に関する対称面を１面だけ持ち、その対称面内のみで偏心していると、結像光学系の製作性が向上し、コストも下がるので好ましい。この場合、形状に関する対称面と垂直方向は広画角を確保しやすいので、この方向を１次元走査光学系の走査方向あるいは２次元走査光学系の走査画角の大きい方向にす

るとよい。このとき、結像光学系を偏心させている面内方向は、偏心した面と面が干渉しないように光学系を構成する必要があるので、結像光学系を構成するのが難しくなる。

【０１０２】そこで、結像光学系を偏心させている方向（結像光学系の形状に関する対称面内方向）の瞳倍率を対称面と垂直方向の瞳倍率より小さくし、結像光学系内での光束の広がり角を小さくした方が結像光学系を構成しやすくなる。

【０１０３】すなわち、次式を満足することが望ましい。

【０１０４】

１＞対称面内の瞳倍率／対称面と直交面内の瞳倍率

ＮＡ２／ＮＡ１＞１

ここで、形状に関する対称面内方向における光源から集光光学系への入射する光束の開口数をＮＡ２、形状に関する対称面と垂直方向における光源から集光光学系への入射する光束の開口数をＮＡ１とする。

【０１０７】この走査光学系は、後記の実施例１～６が対応する。

【０１０８】この走査光学系の作用効果を説明する。結像光学系の形状に関する対称面方向を副走査方向、対称面と垂直方向を主走査方向とする場合、走査面での主走査方向と副走査方向での結像光学系の分解能を等しくするには、光偏向手段の副走査方向の寸法を主走査方向の寸法より大きくする必要が生ずる。

【０１０９】光源を発した光が、走査手段において上記形状になるためには、条件式（２）を満足した方が集光光学系の構成が容易になる。

【０１１０】

【発明の実施の形態】以下に、本発明の走査光学系の実施例１から実施例６について図面を参照して説明する。

【０１１１】以下の説明では、Ｘ方向を主走査方向、Ｙ方向を副走査方向として説明する。

【０１１２】各実施例の逆光線追跡での構成パラメータは後記するが、その各実施例の構成パラメータにおいては、図１に示すように、逆光線追跡で、軸上主光線１を、不図示の被走査面の中心を垂直に通り、光偏向手段１２を経て光源１１の中心に至る光線で定義する。

【０１１３】そして、逆光線追跡において、無偏心状態に戻した第１面４Ｔ（実際にはＹ方向に偏心している。）を偏心光学系の原点とし、軸上主光線１に沿う方向をＺ軸方向とし、被走査面から光学系１０の第１面４Ｔに向かう方向をＺ軸正方向とし、このＺ軸と被走査面中心を含む平面をＹ－Ｚ平面（図１の面）とし、原点を通りＹ－Ｚ平面に直交し、紙面の手前から裏方向に向かう方向をＸ軸正方向とし、Ｘ軸、Ｚ軸と右手直交座標系を構成する軸をＹ軸とする。図１には、この座標系を図示してある。その他の実施例を示す図４～図８については、この座標系の図示は省く。

$= (2\phi_2/\theta_2)/(2\phi_1/\theta_1)$

$= \phi_2\theta_1/\phi_1\theta_2$

結像光学系の形状に関する対称面方向を副走査方向、対称面と垂直方向を主走査方向とする場合、走査面での主走査方向と副走査方向の結像光学系の分解能を等しくするには、光偏向手段の副走査方向の寸法を主走査方向の寸法より大きくする必要が生ずる。２次元走査を行う場合に、高速走査が必要となるの主走査方向の寸法が小さいので、高速走査に対応しやすくなる。

【０１０５】本発明の第２３の走査光学系は、第２２の走査光学系において、以下の条件式を満足することを特徴とするものである。

【０１０６】

・・・（２）

【０１１４】偏心面については、上記座標系の原点から、その面の面頂位置の偏心量（Ｘ軸方向、Ｙ軸方向、Ｚ軸方向をそれぞれＸ，Ｙ，Ｚ）と、その面の中心軸（自由曲面については、前記（ａ）式のＺ軸）のＸ軸、Ｙ軸、Ｚ軸それぞれを中心とする傾き角（それぞれα，β，γ（°））とが与えられている。なお、その場合、αとβの正はそれぞれの軸の正方向に対して反時計回りを、γの正はＺ軸の正方向に対して時計回りを意味する。

【０１１５】実施例１～６では、このＹ－Ｚ平面内で各面の偏心を行っており、また、各回転非対称自由曲面の唯一の対称面をＹ－Ｚ面としている。

【０１１６】また、各実施例の光学系を構成する光学作用面の中、特定の面（仮想面を含む。）とそれに続く面が共軸光学系を構成する場合に、面間隔が与えられており、その他、媒質の屈折率、アッベ数が慣用法に従って与えられている。

【０１１７】また、本発明で用いられる自由曲面の面の形状は前記（ａ）式により定義し、その定義式のＺ軸が自由曲面の軸となる。

【０１１８】また、ＤＯＥ（回折光学素子）については、設計法としてSweatt法（超高屈折率法）を使用し（W.C.Sweatt,"Mathematical equivalence between a holographic optical element and an ultra-high index lens",J.Opt.Soc.Am,Vol.69,No.3(1979)）、基準波長＝５８７．５６ｎｍ（ｄ線）とし、その基準波長における超高屈折率レンズの屈折率＝１００１、アッベ数＝－３．４５とした。

【０１１９】なお、データの記載されていない自由曲面に関する項は０である。屈折率については、ｄ線（波長５８７．５６ｎｍ）に対するものを表記してある。長さの単位はｍｍ、角度の単位は°である。

【０１２０】また、自由曲面の他の定義式として、以下の（ｂ）式で与えられるＺｅｒｎｉｋｅ多項式がある。この面の形状は以下の式により定義する。その定義式のＺ軸がＺｅｒｎｉｋｅ多項式の軸となる。回転非対称面

の定義は、Ｘ－Ｙ面に対するＺの軸の高さの極座標で定義され、ＡはＸ－Ｙ面内のＺ軸からの距離、ＲはＺ軸回りの方位角で、Ｚ軸から測った回転角で表せられる。

【０１２１】

$$
\begin{aligned}
x &= R\times\cos(A)\\
y &= R\times\sin(A)\\
Z &= D_2\\
&+D_3 R\cos(A)+D_4 R\sin(A)\\
&+D_5 R^2 \cos(2A)+D_6 (R^2-1)+D_7 R^2 \sin(2A)\\
&+D_8 R^3\cos(3A)+D_9 (3R^3-2R)\cos(A)\\
&\quad+D_{10}(3R^3-2R)\sin(A)+D_{11}R^3\sin(3A)\\
&+D_{12}R^4\cos(4A)+D_{13}(4R^4-3R^2)\cos(2A)\\
&\quad+D_{14}(6R^4-6R^2+1)+D_{15}(4R^4-3R^2)\sin(2A)\\
&\quad+D_{16}R^4\sin(4A)\\
&+D_{17}R^5\cos(5A)+D_{18}(5R^5-4R^3)\cos(3A)\\
&\quad+D_{19}(10R^5-12R^3+3R)\cos(A)\\
&\quad+D_{20}(10R^5-12R^3+3R)\sin(A)\\
&\quad+D_{21}(5R^5-4R^3)\sin(3A)+D_{22}R^5\sin(5A)\\
&+D_{23}R^6\cos(6A)+D_{24}(6R^6-5R^4)\cos(4A)\\
&\quad+D_{25}(15R^6-20R^4+6R^2)\cos(2A)\\
&\quad+D_{26}(20R^6-30R^4+12R^2-1)\\
&\quad+D_{27}(15R^6-20R^4+6R^2)\sin(2A)\\
&\quad+D_{28}(6R^6-5R^4)\sin(4A)+D_{29}R^6\sin(6A)\cdots\cdots
\end{aligned}
\qquad\cdots(b)
$$

なお、Ｘ軸方向に対称な光学系として設計するには、D_4，D_5，D_6、D_{10}０，D_{11}，D_{12}，D_{13}，D_{14}，D_{20}，D_{21}，D_{22}…を利用する。

【０１２２】その他の面の例として、次の定義式（ｃ）があげられる。

【０１２３】$Z=\Sigma\Sigma C_{nm}XY$例として、ｋ＝７（７次項）を考えると、展開したとき、以下の式で表せる。

【０１２４】

$$
\begin{aligned}
Z &= C_2\\
&+C_3 y+C_4 |x|\\
&+C_5 y^2+C_6 y|x|+C_7 x^2\\
&+C_8 y^3+C_9 y^2|x|+C_{10}y x^2+C_{11}|x^3|\\
&+C_{12}y^4+C_{13}y^3|x|+C_{14}y^2x^2+C_{15}y|x^3|+C_{16}x^4\\
&+C_{17}y^5+C_{18}y^4|x|+C_{19}y^3x^2+C_{20}y^2|x^3|\\
&\qquad+C_{21}y x^4+C_{22}|x^5|\\
&+C_{23}y^6+C_{24}y^5|x|+C_{25}y^4x^2+C_{26}y^3|x^3|\\
&\qquad+C_{27}y^2x^4+C_{28}y|x^5|+C_{29}x^6\\
&+C_{30}y^7+C_{31}y^6|x|+C_{32}y^5x^2+C_{33}y^4|x^3|\\
&\qquad+C_{34}y^3x^4+C_{35}y^2|x^5|+C_{36}y x^6+C_{37}|x^7|
\end{aligned}
\qquad\cdots(c)
$$

なお、本発明の実施例では、前記（ａ）式を用いた自由曲面で面形状が表現されているが、上記（ｂ）式、（ｃ）式を用いても同様の作用効果を得られるのは言うまでもない。

【０１２５】（実施例１）この実施例の走査光学系の光軸を含むＹ－Ｚ平面図（副走査方向面内における断面図）を図１に示す。この走査光学系の水平画角５４°、垂直画角４２°であり、光偏向手段の大きさはφ１ｍｍである。

【０１２６】この走査光学系１０の構成は、図示しない光源輝度変調手段により、映像信号に応じて光源１１を輝度変調し、映像信号に応じた２次元走査（ラスタスキャン）を行うことで、結像光学系の前方の１ｍの位置の被走査面に結像し被走査面を２次元走査するものである。

【０１２７】この走査光学系１０の光路は、光源１１から図示しない像面（被走査面）に到る順光線追跡で、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔで構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、２次元スキャナ１２で反射偏向される。反射偏向された光は、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を２次元走査する。

【０１２８】光源１１として、ＬＥＤ、ＬＤ等が使用できる。複数の単色光源を利用してカラー表示する場合は、例えば、図２に示すようにすればよい。図２において、短波長光、例えば５００ｎｍ以下の波長の光を反射させるダイクロイックミラー２４を直角プリズムからなる光源プリズム２１と光源プリズム２２の接合面にコーティングし、長波長光、例えば６００ｎｍ以上の光を反射させるダイクロイックミラー２５を直角プリズムからなる光源プリズム２２と光源プリズム２３の接合面にコーティングしている。そして、Ｂ光源１１_B、Ｒ光源１１_R、Ｇ光源１１_Gを、それぞれ光源プリズム２１、光源プリズム２２、光源プリズム２３のそれぞれの波長において被走査面の像点と共役な位置に接着し、走査光学系の色収差の影響を除去している。

【０１２９】この構成により、ＲＧＢ光を走査光学系１０に導き、カラー表示を行うことができる。このとき、図示しないＲＧＢ用強度変調装置により、映像信号に基づき各画素ごとにＲＧＢ光のそれぞれを輝度変調する。

【０１３０】走査手段（２次元スキャナ）１２としていくつかのものを使用することができるが、特開平１０－２０２２６号で開示されているようなマイクロマシン技術を利用して製作したマイクロマシンスキャナは、小型、低消費電力等の利点を持つので、小型光学系用としては最適である。

【０１３１】この場合、電磁駆動方式、静電駆動方式、圧電素子駆動方式等、各種駆動方式のマイクロマシンスキャナが使用できる。２次元マイクロマシンスキャナの１例の平面図を図３に示す。この例では、ミラー部３４をＹ軸方向に延びるトーションバー３３で中間枠３２に連結し、その中間枠３２をＸ軸方向に延びるトーションバー３１で外枠３０に連結して、トーションバー３３の回りでの揺動により水平走査（Ｘ方向走査）、トーションバー３１の回りでの揺動により垂直走査（Ｙ方向走査）するようにしている。

【０１３２】一般に、反射面を複数面持つ回転多面鏡（ポリゴンミラー）をスキャナとして使用する場合は、光学系が面倒れ補正機能を持つ必要がある。しかし、図３に示すようなマイクロマシンスキャナは反射面を１面３４しか持たないし、問題となる面倒れはスキャナの構造上発生しないので、光学系が面倒れ補正機能を持つ必要がなく光学系の構成を単純にできる。

【０１３３】この場合、反射面の基準面に対する軸上主光線の入射角θｓ が、次式を満足することが好ましい。

【０１３４】θｓ ≦４５°

この条件の上限の４５°を越えると、同じ光束を反射偏向する場合でも、反射面の面積が大きくなるので、大偏向角や高走査周波数を確保するのが難しくなる。本実施例では、θｓ＝２０°である。

【０１３５】なお、正弦波状に往復振動するスキャナの振れ角の往路だけの片側走査でも、往路と復路両方の往復走査でもどちらでもよいが、往復走査を行うと走査手段の走査周波数を半分にできるので高速走査に対応しやすい。

【０１３６】この実施例の走査光学系１０の利点について説明する。プリズム部材１０の１個で集光光学系と結像光学系を構成しているので、先行例に比べ大幅に部品点数を削減し、光学系が小型化、低コスト化できる。また、部品点数が少ないので位置調整作業が削減でき、製作時に性能を確保するのも容易になる。

【０１３７】また、集光光学系で１回反射、結像光学系で２回反射、スキャナで１回反射の計４回反射しているので、折り畳みの効果により光学系を小型化できている。また、走査光学系１０の主たるパワーを反射面が持つので、色収差の発生が少なく、ＬＤを光源とした場合でもＬＤの波長変動による走査光学系１０の光学性能の変化が少ない。また、凸パワー作用を持つ第２反射面２ｒと凹パワー作用を持つ第３反射面（全反射面）３Ｒの組み合わせにより、走査画角全域における像面湾曲を補正している。

【０１３８】また、反射作用と透過作用を兼ねる兼用面２Ｔ（３Ｔ，３Ｒ）があるので、光学系を構成する面数が削減でき、集光光学系と結像光学系を小型化できている。この面を偏向手段１２に対して凹面形状にした方が、反射作用を全反射作用にしやすい。

【０１３９】また、直線走査性、等速走査性に関して、一般に、反射型走査光学系では直線走査性の確保が問題となる。本実施例では、反射面が偏心収差を補正する回転非対称な形状なので、２次元的な直線走査性を確保している。

【０１４０】２次元走査に必要なスキャンミラー１２の振れ角は、φｘ＝±７．９５°、φｙ＝±３．２０°であり、この場合、正弦波状に振動するスキャンミラーの６５％程度に対して結像光学系がｆアークサインθレンズ特性を持つので、２次元的な直線走査、等速走査を行うことができる（Ｘ方向のスキャンミラー振れ角φｘ＝±１２．２°の振幅の６５％が、Ｘ方向の走査に必要なミラー振れ角φｘ＝±７．９５°。Ｙ方向のスキャンミラー振れ角φｙ＝±４．９３°の振幅の６５％が、Ｙ方向の走査に必要なミラー振れ角φｙ＝±３．２０°。）。

【０１４１】スキャンミラー１２の振れ角が本実施例程度の場合、結像光学系をｆアークサインθレンズにするには、結像光学系でプラスのディストーションを発生させる必要がある。本実施例のように、結像光学系の光学パワーを有する面の中最も被走査面側の面４Ｔを透過作用のみの単独作用面とすることでディストーションの補正を有効に行うことができる。また、画角の確保も容易になる。

【０１４２】なお、結像光学系により形成される非等速走査像を等速走査像に変換する電気的な像歪み補正（等

速走査性の補正）を行えば、正弦波状に振動するスキャンミラー１２の振幅全部を利用することもできるし、スキャンミラー振れ角がリニアに変化するスキャナを利用することもできる。

【０１４３】また、集光光学系にビーム整形機能を持たせている。偏向手段１２をφ１ｍｍとする場合、集光光学系の光源側ＮＡは、Ｘ方向が０．１６、Ｙ方向が０．１９である。

【０１４４】次に、この実施例の変形について述べると、ここでは、点状光源１１を２次元スキャンすることで２次元像を形成しているが、線状のアレー光源を１次元スキャンするようにしてもよい。

【０１４５】また、ここではスキャナのＸ方向の寸法＝Ｙ方向の寸法として設計を行っているが、被走査面側でのＸ方向の分解能とＹ方向の分解能を等しくする等のためにスキャナ１２のＸ方向の寸法≠Ｙ方向の寸法としてもよい。

【０１４６】（実施例２）この実施例の走査光学系の図１と同様の図を図４に示す。この走査光学系の水平画角５４°、垂直画角４２°である。

【０１４７】この走査光学系１０の構成は、実施例１と同様であり、図示しない光源輝度変調手段により、映像信号に応じて光源１１を輝度変調し、映像信号に応じた２次元走査（ラスタスキャン）を行うことで、結像光学系の前方の１ｍの位置の被走査面に結像し被走査面を２次元走査するものである。

【０１４８】この走査光学系１０の光路は、光源１１から図示しない像面（被走査面）に到る順光線追跡で、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔで構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、２次元スキャナ１２で反射偏向される。反射偏向された光は、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を２次元走査する。

【０１４９】この実施例は、実施例１よりｆアークサインθレンズ特性を向上させたタイプである。正弦波状に振動するスキャンミラー１２に対して、Ｘ方向、Ｙ方向共スキャンミラー振れ角振幅の約７０％に対してｆアークサインθレンズ特性を持つ。

【０１５０】なお、ディストーションをコントロールしやす位置であるプリズム１０と被走査面の間等にレンズを追加すれば、ｆアークサインθレンズ特性を更に向上させることができる。

【０１５１】（実施例３）この実施例の走査光学系の図１と同様の図を図５に示す。この走査光学系の水平画角５４°、垂直画角４２°であり、光偏向手段の大きさはφ１ｍｍである。

【０１５２】この走査光学系１０の構成は、実施例１、２と同様であり、図示しない光源輝度変調手段により、映像信号に応じて光源１１を輝度変調し、映像信号に応じた２次元走査（ラスタスキャン）を行うことで、結像光学系の前方の１ｍの位置の被走査面に結像し被走査面を２次元走査するものである。

【０１５３】この走査光学系１０の光路は、光源１１から図示しない像面（被走査面）に到る順光線追跡で、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔで構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、２次元スキャナ１２で反射偏向される。反射偏向された光は、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を２次元走査する。

【０１５４】この実施例は、回転多面鏡（ポリゴン）のように偏向角がリニアに変化する偏向手段１２を使った場合、被走査面で等速走査ができるように結像光学系をｆθレンズ（Ｘ方向の主走査方向、Ｙ方向の副走査方向に関する２次元ｆθレンズ）にしたものである。

【０１５５】（実施例４）この実施例の走査光学系の図１と同様の図を図６に示す。この走査光学系の水平画角４７°、垂直画角３６°であり、光偏向手段の大きさはφ１．１ｍｍである。

【０１５６】この走査光学系１０の構成は、実施例１～３の配置において、プリズム１０とスキャナ１２の間にＤＯＥ（回折光学素子）１３を配置してなるものであり、図示しない光源輝度変調手段により、映像信号に応じて光源１１を輝度変調し、映像信号に応じた２次元走査（ラスタスキャン）を行うことで、結像光学系の前方の１ｍの位置の被走査面に結像し被走査面を２次元走査するものである。

【０１５７】この走査光学系１０の光路は、光源１１から図示しない像面（被走査面）に到る順光線追跡で、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔ、スキャナ１２側の面に回折面１４を設けたＤＯＥ１３で構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、２次元スキャナ１２で反射偏向される。反射偏向された光は、スキャナ１２側の面に回折面１４を設けたＤＯＥ１３、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を２次元走査する。

【０１５８】この実施例は、プリズム１０とスキャナ１２の間にＤＯＥ１３を配置し、走査光学系の色収差を補正したものであり、光源１１から被走査面に向かう順光線追跡で、集光光学系から射出してスキャナ１２へ向かう際とスキャナ１２から結像光学系に入射する際の両方で、ＤＯＥ１３の作用を受けるようにしている。

【０１５９】なお、２次元スキャナ１２としてマイクロマシンスキャナを使用する場合、ＤＯＥ１３を形成した基板をスキャナ１２の保護部材や密閉部材として使用す

る等、スキャナ１２と一体化してもよい。

【０１６０】（実施例５）この実施例の走査光学系の図１と同様の図を図７に示す。この走査光学系１０の構成は、実施例１～３の配置において、光源１１とプリズム１０の間にＤＯＥ１３を配置してなるものであり、図示しない光源輝度変調手段により、映像信号に応じて光源１１を輝度変調し、映像信号に応じた２次元走査（ラスタスキャン）を行うことで、結像光学系の前方の１ｍの位置の被走査面に結像し被走査面を２次元走査するものである。

【０１６１】この走査光学系１０の光路は、光源１１から図示しない像面（被走査面）に到る順光線追跡で、プリズム１０側の面に回折面１４を設けたＤＯＥ１３、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔで構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、２次元スキャナ１２で反射偏向される。反射偏向された光は、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を２次元走査する。

【０１６２】この実施例は、光源１１とプリズム１０の間にＤＯＥ１３を配置し、走査光学系の色収差を補正したものである。

【０１６３】（実施例６）この実施例の走査光学系の図１と同様の図を図８に示す。この走査光学系は水平画角８２°、スキャナの大きさはφ２．６ｍｍの１次元走査光学系である。

【０１６４】この走査光学系１０の構成は、実施例１と略同様であり、図示しない光源輝度変調手段により、映像信号に応じて光源１１を輝度変調し、映像信号に応じた水平方向（Ｘ方向）に１次元走査を行うことで、無偏心状態に戻した第１面４Ｔから前方の１０ｍｍの位置の被走査面に結像し被走査面を１次元走査するものである。

【０１６５】この走査光学系１０の光路は、光源１１から図示しない像面（被走査面）に到る順光線追跡で、第１透過面１Ｔ、第１反射面１Ｒ、第２透過面２Ｔで構成される集光光学系により光源光が略平行にされる。略平行光にされた光源光は、１次スキャナ１２で反射偏向される。反射偏向された光は、第３透過面３Ｔ、第２反射面２Ｒ、第３反射面（全反射）３Ｒ、第４透過面４Ｔで構成される結像光学系により被走査面に結像し被走査面を１次元走査する。

【０１６６】この実施例は、主走査方向（Ｘ方向）は、正弦波状に振れ角が変化するスキャナ１２の振れ角振幅の９５％に対してｆアークサインθレンズ特性を持つ。

【０１６７】以下に上記実施例１～６の構成パラメータ（レンズデータ）を示す。これら表中の“ＦＦＳ”は自由曲面、“ＲＳ”は反射面、“ＤＯＥ”は回折面を示す。なお、スキャナは絞り面に、光源は像面に配置される。

【０１６８】

実施例１

面番号	曲率半径	面間隔	偏心	屈折率	アッベ数
物体面	∞	1000.00			
1	ＦＦＳ①		偏心(1)	1.5254	56.3
2	ＦＦＳ②（ＲＳ）		偏心(2)	1.5254	56.3
3	ＦＦＳ③（ＲＳ）		偏心(3)	1.5254	56.3
4	ＦＦＳ②		偏心(2)		
5	∞（絞り面）		偏心(4)		
6	ＦＦＳ②		偏心(2)	1.5254	56.3
7	ＦＦＳ④（ＲＳ）		偏心(5)	1.5254	56.3
8	ＦＦＳ⑤		偏心(6)		
像　面	∞		偏心(7)		

ＦＦＳ①

C_4	-2.5779×10^{-2}	C_6	-1.2030×10^{-1}	C_8	-1.1075×10^{-2}
C_{10}	-1.8153×10^{-2}	C_{11}	2.5232×10^{-4}	C_{13}	7.6132×10^{-3}
C_{15}	3.4561×10^{-3}	C_{17}	1.9873×10^{-4}	C_{19}	2.2454×10^{-4}
C_{21}	6.3462×10^{-4}	C_{22}	1.9509×10^{-6}	C_{24}	-1.1858×10^{-4}
C_{26}	-2.2337×10^{-4}	C_{28}	-1.0408×10^{-4}		

ＦＦＳ②

C_4	7.7922×10^{-4}	C_6	7.7495×10^{-3}	C_8	3.7699×10^{-3}
C_{10}	-2.3003×10^{-3}	C_{11}	3.8795×10^{-4}	C_{13}	2.1619×10^{-3}
C_{15}	2.1746×10^{-4}	C_{17}	3.0215×10^{-4}	C_{19}	4.7146×10^{-4}
C_{21}	5.4788×10^{-5}	C_{22}	-2.2446×10^{-6}	C_{24}	6.4487×10^{-5}
C_{26}	6.0274×10^{-5}	C_{28}	7.6776×10^{-6}		

ＦＦＳ③

C_4	-2.2371×10^{-2}	C_6	1.1690×10^{-2}	C_8	7.2963×10^{-4}
C_{10}	6.5994×10^{-4}	C_{11}	7.9455×10^{-4}	C_{13}	1.1221×10^{-3}
C_{15}	-1.4706×10^{-5}	C_{17}	-9.7208×10^{-4}	C_{19}	-6.3757×10^{-4}
C_{21}	-3.9919×10^{-5}	C_{22}	-1.0684×10^{-4}	C_{24}	3.3217×10^{-4}
C_{26}	1.1244×10^{-4}	C_{28}	-2.2822×10^{-6}		

ＦＦＳ④

C_4	3.3846×10^{-2}	C_6	2.9857×10^{-2}	C_8	-9.7283×10^{-3}
C_{10}	-5.0879×10^{-3}	C_{11}	-2.5332×10^{-3}	C_{13}	-4.6775×10^{-4}
C_{15}	-1.1206×10^{-3}	C_{17}	2.2389×10^{-3}	C_{19}	1.5076×10^{-3}
C_{21}	-2.6497×10^{-4}	C_{22}	8.4446×10^{-4}	C_{24}	1.6456×10^{-3}
C_{26}	4.9022×10^{-4}	C_{28}	-2.7959×10^{-5}		

ＦＦＳ⑤

C_4	-5.0621×10^{-1}	C_6	-1.9566×10^{-1}	C_8	-2.5991×10^{-1}
C_{10}	-8.7768×10^{-3}	C_{11}	3.1809×10^{-1}	C_{13}	4.2980×10^{-1}
C_{15}	2.6434×10^{-2}				

偏心(1)

X	0.00	Y	-1.50	Z	0.00
α	0.00	β	0.00	γ	0.00

偏心(2)

X	0.00	Y	0.62	Z	4.94
α	-45.15	β	0.00	γ	0.00

偏心(3)

X	0.00	Y	2.80	Z	2.00
α	-73.15	β	0.00	γ	0.00

偏心(4)

X	0.00	Y	-1.00	Z	5.66
α	-52.18	β	0.00	γ	0.00

偏心(5)

X	0.00	Y	2.66	Z	1.68
α	-66.23	β	0.00	γ	0.00

偏心(6)

X	0.00	Y	-3.05	Z	0.58
α	-79.91	β	0.00	γ	0.00

偏心(7)

X	0.00	Y	-3.98	Z	0.78
α	-100.29	β	0.00	γ	0.00

【０１６９】

実施例２

面番号	曲率半径	面間隔	偏心	屈折率	アッベ数
物体面	∞	1000.00			
1	ＦＦＳ①		偏心(1)	1.5254	56.3
2	ＦＦＳ②（ＲＳ）		偏心(2)	1.5254	56.3
3	ＦＦＳ③（ＲＳ）		偏心(3)	1.5254	56.3
4	ＦＦＳ②		偏心(2)		
5	∞（絞り面）		偏心(4)		
6	ＦＦＳ②		偏心(2)	1.5254	56.3
7	ＦＦＳ④（ＲＳ）		偏心(5)	1.5254	56.3
8	ＦＦＳ⑤		偏心(6)		
像　面	∞		偏心(7)		

ＦＦＳ①

C_4	1.2830×10^{-2}	C_6	-1.0765×10^{-1}	C_8	-6.8597×10^{-3}
C_{10}	-7.3302×10^{-3}	C_{11}	6.8784×10^{-5}	C_{13}	2.0958×10^{-3}
C_{15}	4.2746×10^{-3}	C_{17}	-1.4056×10^{-5}	C_{19}	2.1878×10^{-4}
C_{21}	-5.6130×10^{-4}	C_{22}	1.2335×10^{-6}	C_{24}	-8.3175×10^{-6}
C_{26}	-7.0819×10^{-5}	C_{28}	3.5824×10^{-5}		

ＦＦＳ②

C_4	-1.2602×10^{-3}	C_6	6.5870×10^{-3}	C_8	8.6539×10^{-4}
C_{10}	-1.4889×10^{-3}	C_{11}	9.7681×10^{-5}	C_{13}	6.7863×10^{-4}
C_{15}	2.6351×10^{-5}	C_{17}	-7.9227×10^{-6}	C_{19}	1.2881×10^{-4}
C_{21}	4.1327×10^{-5}	C_{22}	-1.3352×10^{-6}	C_{24}	-2.8331×10^{-6}
C_{26}	1.2199×10^{-5}	C_{28}	5.7971×10^{-6}		

ＦＦＳ③

C_4	-1.9853×10^{-2}	C_6	1.2833×10^{-2}	C_8	-5.2848×10^{-4}
C_{10}	3.7366×10^{-4}	C_{11}	2.2434×10^{-4}	C_{13}	6.4856×10^{-4}
C_{15}	1.9609×10^{-6}	C_{17}	2.1708×10^{-5}	C_{19}	-3.0213×10^{-4}
C_{21}	-1.6660×10^{-5}	C_{22}	-3.2798×10^{-5}	C_{24}	-2.4481×10^{-6}
C_{26}	4.3731×10^{-5}	C_{28}	-3.4736×10^{-6}		

ＦＦＳ④

C_4	3.5143×10^{-2}	C_6	2.9244×10^{-2}	C_8	-1.0733×10^{-2}
C_{10}	-4.6492×10^{-3}	C_{11}	-3.7851×10^{-3}	C_{13}	-4.4587×10^{-3}
C_{15}	-1.1223×10^{-3}	C_{17}	-1.5160×10^{-3}	C_{19}	-1.2923×10^{-3}
C_{21}	-3.0248×10^{-4}	C_{22}	-4.5680×10^{-4}	C_{24}	-1.2579×10^{-4}
C_{26}	-1.7631×10^{-4}	C_{28}	-3.7567×10^{-5}		

ＦＦＳ⑤

C_4	-4.7149×10^{-1}	C_6	-1.8302×10^{-1}	C_8	-1.5918×10^{-1}
C_{10}	-1.0259×10^{-2}	C_{11}	1.8967×10^{-1}	C_{13}	2.7011×10^{-1}
C_{15}	2.3839×10^{-2}				

偏心(1)

X	0.00	Y	-1.50	Z	0.00
α	0.00	β	0.00	γ	0.00

偏心(2)

X	0.00	Y	0.91	Z	4.98
α	-46.60	β	0.00	γ	0.00

偏心(3)

X	0.00	Y	2.80	Z	1.83
α	-73.91	β	0.00	γ	0.00

偏心(4)

X	0.00	Y	-1.00	Z	5.62
α	-50.77	β	0.00	γ	0.00

偏心(5)

X	0.00	Y	2.64	Z	1.67
α	-65.89	β	0.00	γ	0.00

偏心(6)

X	0.00	Y	-3.05	Z	0.60
α	-79.70	β	0.00	γ	0.00

偏心(7)

X	0.00	Y	-3.96	Z	0.83
α	-98.37	β	0.00	γ	0.00

【０１７０】

実施例３

面番号	曲率半径	面間隔	偏心	屈折率	アッベ数
物体面	∞	1000.00			
1	ＦＦＳ①		偏心(1)	1.5254	56.3
2	ＦＦＳ②（ＲＳ）		偏心(2)	1.5254	56.3
3	ＦＦＳ③（ＲＳ）		偏心(3)	1.5254	56.3
4	ＦＦＳ②		偏心(2)		
5	∞（絞り面）		偏心(4)		
6	ＦＦＳ②		偏心(2)	1.5254	56.3
7	ＦＦＳ④（ＲＳ）		偏心(5)	1.5254	56.3
8	ＦＦＳ⑤		偏心(6)		
像　面	∞		偏心(7)		

ＦＦＳ①

C_4	2.0048×10^{-3}	C_6	-6.5253×10^{-2}	C_8	-2.1891×10^{-3}
C_{10}	-5.2349×10^{-2}	C_{11}	4.3385×10^{-4}	C_{13}	2.5336×10^{-3}
C_{15}	8.2781×10^{-3}	C_{17}	-2.3112×10^{-5}	C_{19}	-4.8161×10^{-4}
C_{21}	3.6053×10^{-3}	C_{22}	-5.0443×10^{-6}	C_{24}	-1.0024×10^{-5}
C_{26}	4.9410×10^{-5}	C_{28}	-8.4784×10^{-4}		

ＦＦＳ②

C_4	9.3276×10^{-3}	C_6	1.2305×10^{-2}	C_8	3.3701×10^{-3}
C_{10}	6.2067×10^{-4}	C_{11}	-2.6194×10^{-4}	C_{13}	5.5084×10^{-4}
C_{15}	-1.7807×10^{-4}	C_{17}	-9.2688×10^{-5}	C_{19}	2.3851×10^{-4}
C_{21}	-6.1960×10^{-5}	C_{22}	1.1482×10^{-7}	C_{24}	-7.7827×10^{-6}
C_{26}	4.1871×10^{-5}	C_{28}	8.9363×10^{-6}		

ＦＦＳ③

C_4	-1.1936×10^{-2}	C_6	1.5613×10^{-2}	C_8	9.8371×10^{-4}
C_{10}	-3.2433×10^{-4}	C_{11}	-5.0154×10^{-4}	C_{13}	3.1318×10^{-3}
C_{15}	-6.5157×10^{-6}	C_{17}	-2.8893×10^{-4}	C_{19}	-1.1561×10^{-3}
C_{21}	3.2209×10^{-5}	C_{22}	3.9739×10^{-5}	C_{24}	7.0920×10^{-5}
C_{26}	1.2812×10^{-4}	C_{28}	-3.3532×10^{-6}		

ＦＦＳ④

C_4	2.1168×10^{-2}	C_6	3.1444×10^{-2}	C_8	-1.2773×10^{-2}
C_{10}	-4.9250×10^{-3}	C_{11}	1.8772×10^{-4}	C_{13}	-9.2233×10^{-4}
C_{15}	-1.2437×10^{-3}	C_{17}	2.5286×10^{-2}	C_{19}	4.5186×10^{-3}
C_{21}	-3.0342×10^{-4}	C_{22}	1.6796×10^{-2}	C_{24}	1.3450×10^{-2}
C_{26}	1.6931×10^{-3}	C_{28}	-2.7316×10^{-5}		

ＦＦＳ⑤

C_4	-7.6734×10^{-1}	C_6	-2.4281×10^{-1}	C_8	1.0370×10^{-2}
C_{10}	-3.9036×10^{-2}	C_{11}	5.0781×10^{-1}	C_{13}	3.5355×10^{-1}
C_{15}	5.0029×10^{-2}				

偏心(1)

X	0.00	Y	-1.50	Z	0.00
α	0.00	β	0.00	γ	0.00

偏心(2)

X	0.00	Y	1.00	Z	5.00
α	-44.98	β	0.00	γ	0.00

偏心(3)

X	0.00	Y	2.76	Z	1.84
α	-75.17	β	0.00	γ	0.00

偏心(4)

X	0.00	Y	−1.00	Z	4.95
α	−60.82	β	0.00	γ	0.00

偏心(5)

X	0.00	Y	2.60	Z	1.61
α	−67.95	β	0.00	γ	0.00

偏心(6)

X	0.00	Y	−3.01	Z	0.75
α	−83.98	β	0.00	γ	0.00

偏心(7)

X	0.00	Y	−3.97	Z	0.94
α	−98.76	β	0.00	γ	0.00

【０１７１】

実施例４

面番号	曲率半径	面間隔	偏心	屈折率	アッベ数
物体面	∞	1000.00			
1	ＦＦＳ①		偏心(1)	1.5254	56.3
2	ＦＦＳ②（ＲＳ）		偏心(2)	1.5254	56.3
3	ＦＦＳ③（ＲＳ）		偏心(3)	1.5254	56.3
4	ＦＦＳ②		偏心(2)		
5	∞		偏心(4)	1.5254	56.3
6	∞		偏心(5)	1001.00	−3.45
7	ＦＦＳ④（ＤＯＥ）		偏心(6)		
8	∞（絞り面）		偏心(7)		
9	ＦＦＳ④（ＤＯＥ）		偏心(6)	1001.00	−3.45
10	∞		偏心(5)	1.5254	56.3
11	∞		偏心(4)		
12	ＦＦＳ②		偏心(2)	1.5254	56.3
13	ＦＦＳ⑤（ＲＳ）		偏心(8)	1.5254	56.3
14	ＦＦＳ⑥		偏心(9)		
像　面	∞		偏心(10)		

ＦＦＳ①

C_4	-5.1153×10^{-3}	C_6	1.3925×10^{-2}	C_8	-7.3841×10^{-3}
C_{10}	-1.1875×10^{-2}	C_{11}	-7.5853×10^{-5}	C_{13}	1.2571×10^{-3}
C_{15}	1.6283×10^{-3}	C_{17}	5.6232×10^{-5}	C_{19}	2.0110×10^{-4}
C_{21}	-4.8468×10^{-4}	C_{22}	9.0171×10^{-7}	C_{24}	-1.1171×10^{-5}
C_{26}	-2.0169×10^{-5}	C_{28}	6.5369×10^{-5}		

ＦＦＳ②

C_4	1.4932×10^{-2}	C_6	-1.9540×10^{-3}	C_8	4.4504×10^{-3}
C_{10}	-2.4909×10^{-3}	C_{11}	6.1319×10^{-5}	C_{13}	8.8673×10^{-4}
C_{15}	-2.8323×10^{-4}	C_{17}	7.3968×10^{-6}	C_{19}	4.5864×10^{-5}
C_{21}	-2.3171×10^{-6}	C_{22}	5.2961×10^{-8}	C_{24}	-4.5057×10^{-7}
C_{26}	-2.4771×10^{-6}	C_{28}	1.8540×10^{-6}		

ＦＦＳ③

C_4	-2.9939×10^{-3}	C_6	-1.1909×10^{-2}	C_8	1.2713×10^{-2}
C_{10}	-9.0051×10^{-4}	C_{11}	-1.3110×10^{-4}	C_{13}	-4.5404×10^{-3}
C_{15}	5.2681×10^{-4}	C_{17}	4.0962×10^{-5}	C_{19}	1.1500×10^{-3}
C_{21}	7.2718×10^{-5}	C_{22}	-1.2274×10^{-6}	C_{24}	-7.7261×10^{-6}
C_{26}	-1.0427×10^{-4}	C_{28}	-2.2896×10^{-5}		

ＦＦＳ④

C_4	-6.1596×10^{-7}	C_6	3.4175×10^{-6}	C_8	-3.2523×10^{-6}

C_{10}	-9.3052×10^{-7}	C_{11}	-4.0783×10^{-7}	C_{13}	-5.9660×10^{-6}
C_{15}	-2.3863×10^{-6}	C_{17}	-2.8541×10^{-7}	C_{19}	-1.9365×10^{-6}
C_{21}	-5.8348×10^{-7}				

ＦＦＳ⑤

C_4	2.3949×10^{-2}	C_6	3.3604×10^{-2}	C_8	-5.7943×10^{-4}
C_{10}	9.6778×10^{-4}	C_{11}	-8.4834×10^{-4}	C_{13}	-4.2016×10^{-3}
C_{15}	2.3946×10^{-4}	C_{17}	-3.0987×10^{-3}	C_{19}	2.4318×10^{-3}
C_{21}	-4.9242×10^{-4}	C_{22}	7.0481×10^{-4}	C_{24}	-2.4279×10^{-3}
C_{26}	-1.3842×10^{-3}	C_{28}	1.6279×10^{-4}		

ＦＦＳ⑥

C_4	-1.0093	C_6	-2.4736×10^{-1}	C_8	-1.4848
C_{10}	-1.3260×10^{-2}	C_{11}	2.9043×10^{-1}	C_{13}	-8.9842×10^{-1}
C_{15}	5.2718×10^{-2}				

偏心(1)

X	0.00	Y	-1.50	Z	0.00
α	0.00	β	0.00	γ	0.00

偏心(2)

X	0.00	Y	1.12	Z	5.50
α	-50.08	β	0.00	γ	0.00

偏心(3)

X	0.00	Y	3.00	Z	2.00
α	-87.13	β	0.00	γ	0.00

偏心(4)

X	0.00	Y	0.07	Z	5.03
α	-50.80	β	0.00	γ	0.00

偏心(5)

X	0.00	Y	0.11	Z	5.46
α	-50.799815	β	0.00	γ	0.00

偏心(6)

X	0.00	Y	0.57	Z	6.03
α	-50.799876	β	0.00	γ	0.00

偏心(7)

X	0.00	Y	-0.88	Z	5.60
α	-59.62	β	0.00	γ	0.00

偏心(8)

X	0.00	Y	2.60	Z	1.00
α	-67.35	β	0.00	γ	0.00

偏心(9)

X	0.00	Y	-3.00	Z	1.11
α	-107.34	β	0.00	γ	0.00

偏心(10)

X	0.00	Y	-3.84	Z	0.84
α	-83.74	β	0.00	γ	0.00

【０１７２】

実施例５

面番号	曲率半径	面間隔	偏心	屈折率	アッベ数
物体面	∞	1000.00			
1	ＦＦＳ①		偏心(1)	1.5254	56.3
2	ＦＦＳ②（ＲＳ）		偏心(2)	1.5254	56.3
3	ＦＦＳ③（ＲＳ）		偏心(3)	1.5254	56.3

4	ＦＦＳ②	偏心(2)		
5	∞（絞り面）	偏心(4)		
6	ＦＦＳ②	偏心(2)	1.5254	56.3
7	ＦＦＳ④（ＲＳ）	偏心(5)	1.5254	56.3
8	ＦＦＳ⑤	偏心(6)		
9	ＦＦＳ⑥（ＤＯＥ）	偏心(7)	1001.00	-3.45
10	∞	偏心(8)	1.5254	56.3
11	∞	偏心(9)		
像 面	∞	偏心(10)		

ＦＦＳ①

C_4	2.7110×10^{-3}	C_6	-4.1822×10^{-2}	C_8	-8.3156×10^{-3}
C_{10}	-2.6287×10^{-2}	C_{11}	-8.1512×10^{-6}	C_{13}	4.1432×10^{-3}
C_{15}	-6.5747×10^{-4}	C_{17}	2.9008×10^{-6}	C_{19}	1.9125×10^{-4}
C_{21}	2.6876×10^{-4}	C_{22}	-8.9097×10^{-6}	C_{24}	-7.0018×10^{-5}
C_{26}	2.5234×10^{-6}	C_{28}	-3.2872×10^{-5}		

ＦＦＳ②

C_4	-6.3232×10^{-3}	C_6	6.0261×10^{-3}	C_8	-3.2915×10^{-4}
C_{10}	-4.4498×10^{-3}	C_{11}	-1.7090×10^{-5}	C_{13}	1.7254×10^{-3}
C_{15}	7.9047×10^{-4}	C_{17}	-1.5791×10^{-4}	C_{19}	3.8668×10^{-4}
C_{21}	6.0282×10^{-5}	C_{22}	-1.8162×10^{-5}	C_{24}	-3.4431×10^{-5}
C_{26}	5.1730×10^{-5}	C_{28}	9.2060×10^{-7}		

ＦＦＳ③

C_4	-1.6315×10^{-2}	C_6	1.2307×10^{-2}	C_8	-1.8756×10^{-3}
C_{10}	6.2970×10^{-4}	C_{11}	9.5379×10^{-5}	C_{13}	1.3103×10^{-3}
C_{15}	-1.1967×10^{-4}	C_{17}	-2.8876×10^{-5}	C_{19}	-8.6467×10^{-4}
C_{21}	-5.1857×10^{-5}	C_{22}	-8.1252×10^{-5}	C_{24}	1.2131×10^{-4}
C_{26}	1.3258×10^{-4}	C_{28}	6.3820×10^{-6}		

ＦＦＳ④

C_4	2.9891×10^{-2}	C_6	3.0951×10^{-2}	C_8	-9.3571×10^{-3}
C_{10}	-5.2875×10^{-3}	C_{11}	-5.1673×10^{-3}	C_{13}	-5.1317×10^{-4}
C_{15}	-1.1087×10^{-3}	C_{17}	2.6635×10^{-3}	C_{19}	1.8630×10^{-3}
C_{21}	-2.6829×10^{-4}	C_{22}	3.4886×10^{-3}	C_{24}	1.8096×10^{-3}
C_{26}	8.2598×10^{-4}	C_{28}	-2.4770×10^{-5}		

ＦＦＳ⑤

C_4	-6.8396×10^{-1}	C_6	-2.0892×10^{-1}	C_8	-1.7517×10^{-1}
C_{10}	-1.2761×10^{-2}	C_{11}	4.5728×10^{-1}	C_{13}	5.5687×10^{-1}
C_{15}	3.3352×10^{-2}				

ＦＦＳ⑥

C_4	1.0559×10^{-4}	C_6	3.9513×10^{-5}	C_8	1.8847×10^{-4}
C_{10}	1.6785×10^{-4}	C_{11}	-2.8750×10^{-4}	C_{13}	-4.6702×10^{-3}
C_{15}	3.1902×10^{-5}	C_{17}	4.4625×10^{-3}	C_{19}	2.0071×10^{-2}
C_{21}	-4.6995×10^{-5}				

偏心(1)

X	0.00	Y	-1.50	Z	0.00
α	0.00	β	0.00	γ	0.00

偏心(2)

X	0.00	Y	0.34	Z	4.92
α	-50.44	β	0.00	γ	0.00

偏心(3)

X	0.00	Y	2.80	Z	1.89

α	-74.09	β	0.00	γ	0.00
		偏心(4)			
X	0.00	Y	-0.82	Z	5.86
α	-46.70	β	0.00	γ	0.00
		偏心(5)			
X	0.00	Y	2.64	Z	1.68
α	-66.07	β	0.00	γ	0.00
		偏心(6)			
X	0.00	Y	-3.05	Z	0.54
α	-81.32	β	0.00	γ	0.00
		偏心(7)			
X	0.00	Y	-3.34	Z	0.76
α	-99.9998651	β	0.00	γ	0.00
		偏心(8)			
X	0.00	Y	-3.36	Z	0.83
α	-100.00	β	0.00	γ	0.00
		偏心(9)			
X	0.00	Y	-3.79	Z	0.66
α	-100.00	β	0.00	γ	0.00
		偏心(10)			
X	0.00	Y	-4.00	Z	0.71
α	-101.17	β	0.00	γ	0.00

【０１７３】

実施例６

面番号	曲率半径	面間隔	偏心	屈折率	アッベ数
物体面	∞	10.00			
1	ＦＦＳ①		偏心(1)	1.5254	56.3
2	ＦＦＳ②（ＲＳ）		偏心(2)	1.5254	56.3
3	ＦＦＳ③（ＲＳ）		偏心(3)	1.5254	56.3
4	ＦＦＳ②		偏心(2)		
5	∞（絞り面）		偏心(4)		
6	ＦＦＳ②		偏心(2)	1.5254	56.3
7	ＦＦＳ④（ＲＳ）		偏心(5)	1.5254	56.3
8	ＦＦＳ⑤		偏心(6)		
像　面	∞		偏心(7)		

ＦＦＳ①

C_4	-1.4579×10^{-2}	C_6	-1.0257×10^{-1}	C_8	-9.2040×10^{-4}
C_{10}	-1.0489×10^{-2}	C_{11}	-9.9035×10^{-5}	C_{13}	5.9168×10^{-3}
C_{15}	4.8469×10^{-3}	C_{17}	-8.7514×10^{-6}	C_{19}	1.2191×10^{-3}
C_{21}	-9.9794×10^{-4}				

ＦＦＳ②

C_4	1.3960×10^{-2}	C_6	1.2346×10^{-2}	C_8	2.4723×10^{-3}
C_{10}	1.0147×10^{-4}	C_{11}	-1.6176×10^{-4}	C_{13}	8.1886×10^{-4}
C_{15}	2.0947×10^{-5}	C_{17}	-1.7977×10^{-4}	C_{19}	4.1117×10^{-5}
C_{21}	-1.1700×10^{-4}				

ＦＦＳ③

C_4	9.3942×10^{-3}	C_6	1.7229×10^{-2}	C_8	2.3970×10^{-3}
C_{10}	3.5790×10^{-5}	C_{11}	2.9999×10^{-4}	C_{13}	3.8118×10^{-5}
C_{15}	-1.6410×10^{-4}	C_{17}	-1.3152×10^{-4}	C_{19}	-1.6937×10^{-5}
C_{21}	-5.3560×10^{-6}				

ＦＦＳ④

C_4	4.6653×10^{-2}	C_6	3.4104×10^{-2}	C_8	-1.6228×10^{-2}
C_{10}	-7.5431×10^{-3}	C_{11}	-3.0449×10^{-3}	C_{13}	-1.8865×10^{-3}
C_{15}	7.5485×10^{-4}	C_{17}	1.5596×10^{-3}	C_{19}	1.3141×10^{-3}
C_{21}	4.0652×10^{-4}				

ＦＦＳ⑤

C_4	-3.3176×10^{-1}	C_6	-1.4184×10^{-1}	C_8	2.4167×10^{-1}
C_{10}	1.2728×10^{-1}	C_{11}	8.8749×10^{-2}	C_{13}	-1.0491×10^{-1}
C_{15}	-6.7796×10^{-2}				

		偏心(1)			
X	0.00	Y	0.58	Z	0.00
α	0.00	β	0.00	γ	0.00
		偏心(2)			
X	0.00	Y	1.20	Z	4.13
α	-47.90	β	0.00	γ	0.00
		偏心(3)			
X	0.00	Y	1.40	Z	0.70
α	-68.85	β	0.00	γ	0.00
		偏心(4)			
X	0.00	Y	-1.00	Z	4.40
α	-48.05	β	0.00	γ	0.00
		偏心(5)			
X	0.00	Y	1.78	Z	1.68
α	-65.43	β	0.00	γ	0.00
		偏心(6)			
X	0.00	Y	-1.39	Z	1.33
α	-61.77	β	0.00	γ	0.00
		偏心(7)			
X	0.00	Y	-2.47	Z	1.04
α	-97.55	β	0.00	γ	0.00

【０１７４】上記各実施例における条件式（１）、（２）関係の値は以下の通りである。なお、主光線に対する上側マージナル光線と下側マージナル光線が非対称な場合は、両者の平均によりＮＡｙ（ＮＡ２）を求めた。

実施例	走査に必要なスキャナ振れ角（°）		瞳倍率		X瞳倍率／Y瞳倍率	光源側ＮＡ		
	φｙ	φｘ	X瞳倍率 ２φｘ／θｘ	Y瞳倍率 ２φｙ／θｙ		ＮＡｘ (NA1)	ＮＡｙ (NA2)	ＮＡｘ／ＮＡｙ (NA1/NA2)
1	±7.95	±3.20	0.59	0.30	0.52	0.16	0.19	1.20
2	±10.6	±4.42	0.79	0.42	0.54	0.15	0.19	1.28
3	±12.6	±4.87	0.93	0.46	0.50	0.25	0.26	1.02
4	±12.2	±6.10	1.04	0.68	0.65	0.13	0.18	1.41
5	±10.0	±2.45	0.74	0.23	0.32	0.14	0.26	1.91
6	±20.5					0.22	0.37	1.73

【０１７５】以上の実施例では、前記定義式（ａ）の自由曲面により光学系を構成したが、他の定義の曲面でも光学系を構成できることはいうまでもない。

【０１７６】以上、本発明の走査光学系を実施例に基づいて説明してきたが、本発明はこれらの実施例に限定されず数々の変形が可能である。

【０１７７】以上の本発明の走査光学系は例えば次のように構成することができる。

【０１７８】〔１〕　光源からの光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記結像光学系が光学部材を含み、前記光学部材の光学パワーを有する面の中最も被走査面側の面が透過作用の単独作用面で、前記光学部材が光学パワーを有し軸上主光線に対して偏心した非回転対称面を少なくとも１面含む２面以上の反射面を含むことを特徴とする走査光学系。

【０１７９】〔２〕　前記光学部材がプリズム部材として構成されていることを特徴とする上記１記載の走査光学系。

【０１８０】〔３〕　前記光学部材が透過と反射の兼用面を少なくとも１面含むことを特徴とする上記１記載の走査光学系。

【０１８１】〔４〕　前記プリズム部材が透過と反射の兼用面を１面含む３面構成であることを特徴とする上記２記載の走査光学系。

【０１８２】〔５〕　光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記集光光学系から射出して前記光偏向手段に入射する前記集光光学系の最後の面と、前記光偏向手段から前記結像光学系に入射する前記結像光学系の最初の面が同一面であることを特徴とする走査光学系。

【０１８３】〔６〕　前記光偏向手段の前後の光学作用面が透過面であることを特徴とする上記５記載の走査光学系。

【０１８４】〔７〕　前記結像光学系が透過と反射の兼用面を少なくとも１面含むことを特徴とする上記５記載の走査光学系。

【０１８５】〔８〕　光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記走査光学系がプリズム部材を含み、前記プリズム部材は、少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含むことを特徴とする走査光学系。

【０１８６】〔９〕　前記集光光学系と前記結像光学系が一つのプリズム部材で構成されていることを特徴とする上記８記載の走査光学系。

【０１８７】〔１０〕光源と、前記光源からの光を略平行光にする集光光学系と、前記集光光学系からの射出光を偏向して被走査面上で走査する光偏向手段と、前記光偏向手段により偏向された光を被走査面に結像する結像光学系とからなる走査光学系において、前記集光光学系と前記結像光学系との合計で３回以上反射することを特徴とする上記１、５又は８記載の走査光学系。

【０１８８】〔１１〕　少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含む前記プリズム部材が透過と反射の兼用面を持つことを特徴とする上記８記載の走査光学系。

【０１８９】〔１２〕　少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含む前記プリズム部材が２回の透過作用と１回の反射作用の３つの光学作用を行う兼用面を持つことを特徴とする上記１１記載の走査光学系。

【０１９０】〔１３〕　少なくとも前記集光光学系の一部、及び、少なくとも前記結像光学系の一部を含む前記プリズム部材において、前記プリズム部材に含まれる前記集光光学系の部分が、少なくとも、前記プリズム部材への入射面、光学パワーを有し軸上主光線に対して偏心した非回転対称面な反射面、プリズム部材からの射出面の３面を含み、前記プリズム部材に含まれる前記結像光学系の部分が、少なくとも、前記プリズム部材への再入射面、光学パワーを有し軸上主光線に対して偏心した非回転対称面な反射面、プリズム部材からの再射出面の３面を含むことを特徴とする上記８記載の走査光学系。

【０１９１】〔１４〕　前記結像光学系の非回転対称面が形状に関する対称面を１つだけ持つことを特徴とする

$$\phi_2 \theta_1 / \phi_1 \theta_2 < 1$$

ここで、被走査面側の対称面内方向における結像光学系の半画角をθ_2、対称面と直交面方向における結像光学系の半画角をθ_1、対称面方向の被走査面の走査に必要な光偏向手段の片側偏向角を２ϕ_2、対称面と直交面方向の被走査面の走査に必要な光偏向手段の片側偏向角を

$$NA2 / NA1 > 1$$

ここで、形状に関する対称面内方向における光源から集光光学系への入射する光束の開口数をＮＡ２、形状に関する対称面と垂直方向における光源から集光光学系への入射する光束の開口数をＮＡ１とする。

【０２０３】

【発明の効果】本発明は、走査光学系を反射作用を含むプリズム部材を中心に構成することにより、走査光学系の部品点数を削減し、光学系を小型にすることができる。

【図面の簡単な説明】

【図１】本発明の実施例１の走査光学系の光路図である。

【図２】複数の単色光源を利用してカラー表示する場合の光源の構成例を示す図である。

上記１、５又は８記載の走査光学系。

【０１９２】〔１５〕　前記集光光学系が形状に関する対称面を１つだけ持つ非回転対称面を含むことを特徴とする上記１、５又は８記載の走査光学系。

【０１９３】〔１６〕　前記結像光学系の非回転対称面が形状に関する対称面を１つだけ持つ自由曲面であることを特徴とする上記１、５又は８記載の走査光学系。

【０１９４】〔１７〕　前記光偏向手段が、１個の光偏向手段で２次元偏向する２次元光偏向手段であることを特徴とする上記１、５又は８記載の走査光学系。

【０１９５】〔１８〕　前記光偏向手段による偏向角が正弦波状に変化することを特徴とする上記１、５又は８記載の走査光学系。

【０１９６】〔１９〕　前記の偏向角が正弦波状に変化する光偏向手段において、光偏向角の振幅の９５％以下を走査に利用することを特徴とする上記１８記載の走査光学系。

【０１９７】〔２０〕　電気的な等速走査性の補正を行うことを特徴とする上記１、５又は８記載の走査光学系。

【０１９８】〔２１〕　前記光偏向手段による偏向角がリニアに変化することを特徴とする上記１、５又は８記載の走査光学系。

【０１９９】〔２２〕　前記結像光学系が、形状に関する対称面を１つだけ持ち、その形状に関する対称面内方向のみで偏心しており、前記走査光学系が、次式を満足することを特徴とする上記１、５又は８記載の走査光学系。

【０２００】

・・・（１）

２ϕ_1とする。

【０２０１】〔２３〕　以下の条件式を満足することを特徴とする上記２２記載の走査光学系。

【０２０２】

・・・（２）

【図３】２次元マイクロマシンスキャナの１例の平面図である。

【図４】本発明の実施例２の走査光学系の光路図である。

【図５】本発明の実施例３の走査光学系の光路図である。

【図６】本発明の実施例４の走査光学系の光路図である。

【図７】本発明の実施例５の走査光学系の光路図である。

【図８】本発明の実施例６の走査光学系の光路図である。

【図９】反射型光偏向手段と透過型光偏向手段の基本形構成を示す図である。

【図１０】従来の１つの走査光学系の構成を示す図である。

【図１１】従来の別のもう１つの走査光学系の構成を示す図である。

【符号の説明】

１…軸上主光線

１Ｔ…第１透過面

１Ｒ…第１反射面

２Ｔ…第２透過面

２Ｒ…第２反射面

３Ｔ…第３透過面

３Ｒ…第３反射面（全反射）

４Ｔ…第４透過面

１０…走査光学系（プリズム）

１１…光源

１１_B…Ｂ光源

１１_R…Ｒ光源

１１_G…Ｇ光源

１２…光偏向手段（スキャナ）

１３…ＤＯＥ（回折光学素子）

１４…回折面

２１、２２、２３…光源プリズム

２４、２５…ダイクロイックミラー

３０…外枠

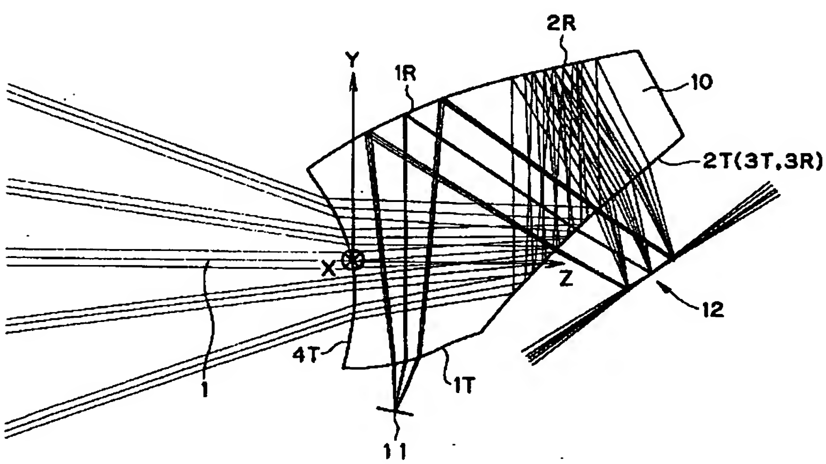
３１…トーションバー

３２…中間枠

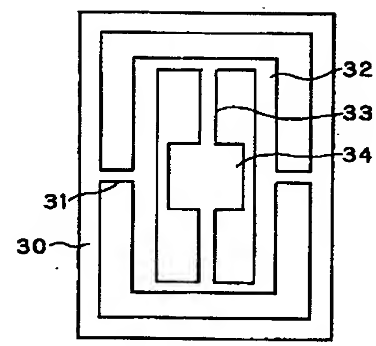
３３…トーションバー

３４…ミラー部

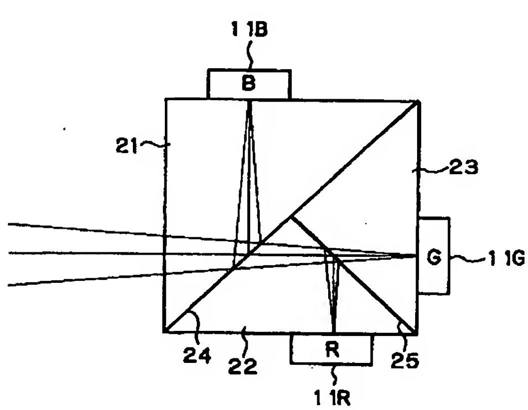
【図１】



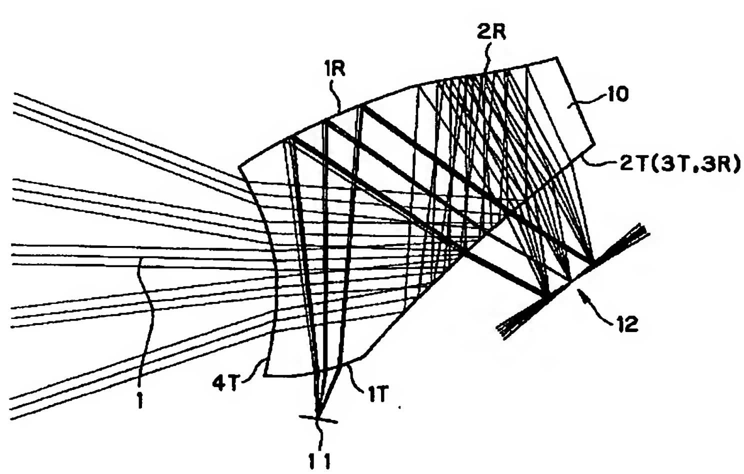
【図３】



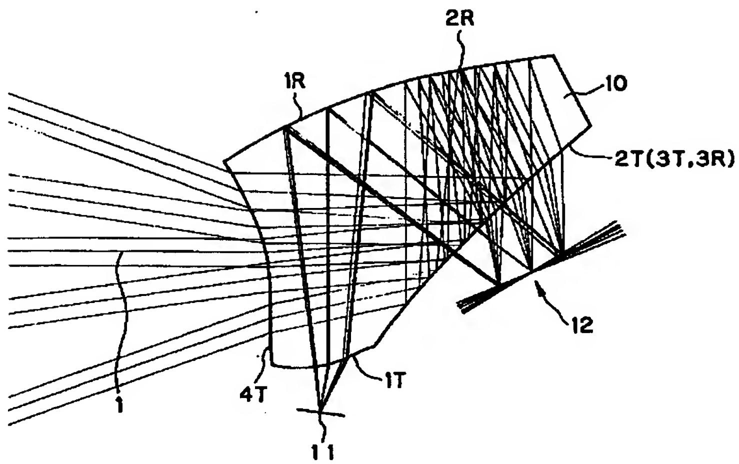
【図２】



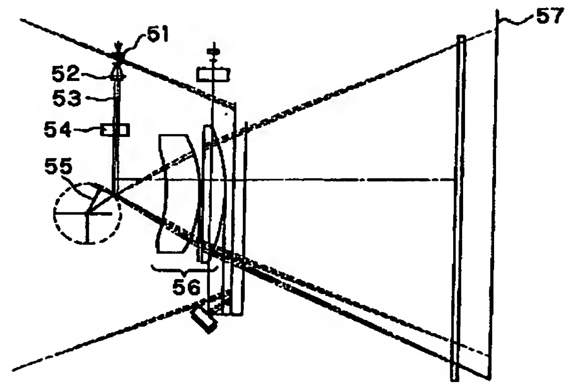
【図４】



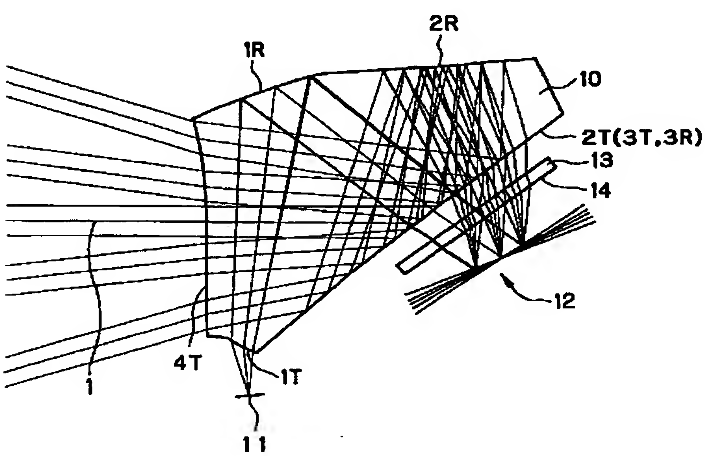
【図５】



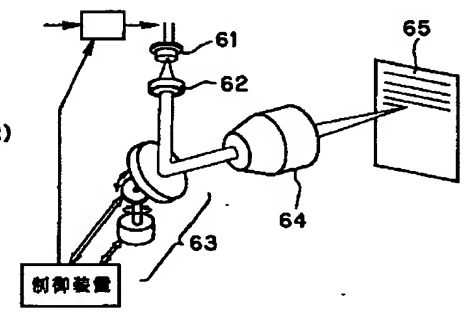
【図１０】



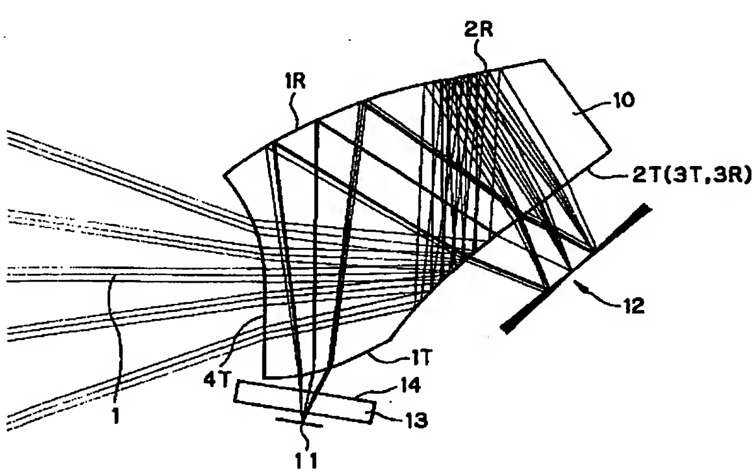
【図６】



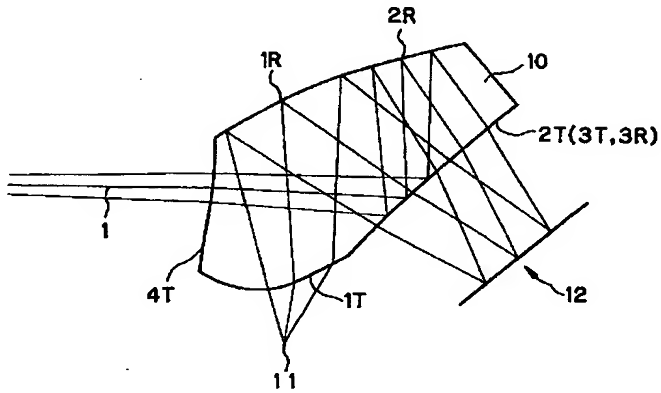
【図１１】



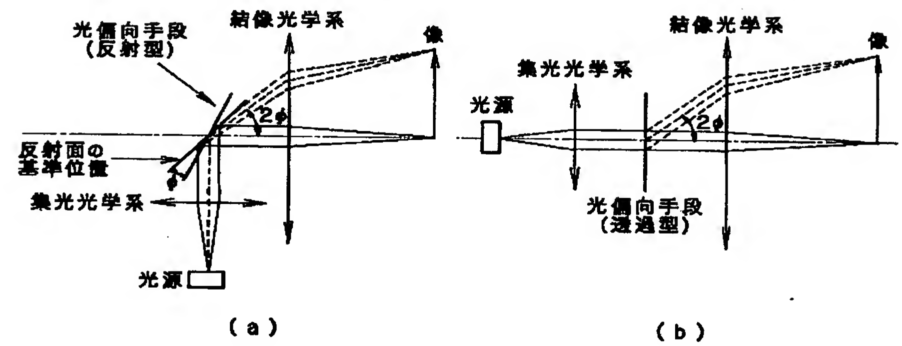
【図７】



【図８】


2R
1R
10
2T(3T,3R)
1
4T
1T
12
11

【図９】


光偏向手段
(反射型)
結像光学系
像
2φ
反射面の
基準位置
φ
集光光学系
光源
(a)
結像光学系
像
集光光学系
光源
2φ
光偏向手段
(透過型)
(b)

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